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LYNX AND GROUSE.

In the spring of the year the peculiar note of the grouse is heard early in the morning, and is welcomed with joy by the huntsman. Usually the grouse is very shy and careful; but while giving his call he seems to be absolutely blind and deaf, and the huntsmen never fail to make full use of this momentary carelessness of the bird. While calling, the grouse generally stands on the lower limbs of old trees, but some of these birds prefer to stand on the ground, and they invariably become the prey of some four-footed epicurean. Among these the lynx is the most dangerous; he prowls about the bird, and is not noticed by the same as it struts about in turkey style. The lynx never misses his chance, and if once near the grouse does not fail to catch it.—*Illustrirte Zeitung.*

THE LYNX AND GROUSE.—DRAWN BY LUDWIG BECKMANN.

THE ASIATIC ELEPHANT IN FREEDOM AND CAPTIVITY.*

By G. P. Sanderson, Superintendent of Government Elephant-catching Operations in Bengal.

While the popular interest felt in the elephant is perhaps greater than that attaching to any other wild animal, I think it may be safely said that regarding none, tame or wild, do more fallacious impressions exist.

The peculiar opportunities which have been afforded me during fifteen out of nearly twenty years spent in India, of observing the elephant in its wild and domesticated states—opportunities which it has been at once my duty as a public servant and my delight as a sportsman to make the most of—have induced me to believe that what I may be able to tell you to-night, regarding some of the most interesting features of the Asiatic elephant, may be acceptable to you, as being facts, and perhaps be of some small service to the cause of natural history. I will first commence with a few remarks on the elephant's intelligence.

The elephant's size and staid appearance, its gentleness, and the ease with which it performs various services with its trunk, have given rise to the exalted idea of its intellect that prevails among those not intimately acquainted with it. And its being but little known in Europe, while what is known of it justly makes it a favorite, leads to tales of its intelligence being not only welcomed with pleasure, but accepted without investigation. Many elephant stories are intended for the amusement of little folk; but in a sober inquiry into the mental capacity of the animal, they must not be accepted.

* A paper lately read before the Society of Arts, London.

The opinion is generally held by those who have had the best opportunities of observing the elephant, that the popular estimate of its intelligence is a greatly exaggerated one; that instead of being an exceptionally wise animal, its sagacity is of a very mediocre description. The truth of this opinion no one who has lived among elephants can doubt. It is a significant fact that the natives of India never speak of the elephant as a peculiarly intelligent animal, and it does not figure in their ancient literature for its wisdom, as do the fox, the crow, and the monkey.

One of the strongest features in the domesticated elephant's character is its obedience. It may also be readily taught, as it has a large share of the ordinary cultivable intelligence common, in a greater or less degree, to all animals. But its reasoning facilities are undoubtedly far below those of the dog, and possibly of other animals; and in matters beyond the range of its daily experience it evinces no special discernment. While fairly quick at comprehending anything sought to be taught to it, the elephant is decidedly wanting in originality. To begin with, the elephant displays less intelligence in its natural state than most wild animals. Whole herds are driven into ill-concealed inclosures, which no other forest creatures could be got to enter; and though these inclosures are made immensely strong, and are generally capable of resisting the efforts of any single elephant, they would not for a moment withstand the combined attack of even two or three, much less of a whole herd. But elephants never thus combine to free themselves. I have frequently seen fifty or sixty crowded into a stockade only thirty yards in diameter, the palisades of which would have been of no more account than cornstalks before the rush of three or four of them, but no such rush has been made. More significant still, I have, on several occasions, seen a single elephant in a herd, by a bold dash, burst through the palisade and effect its escape, but I never yet saw any other elephant follow, and the hunters have at once repaired the breach.

When a herd of wild elephants is secured within a stockade, or *kheddah*, the mahouts ride trained elephants among the wild ones without fear, though any one of the wild ones might, by a movement of its trunk, dislodge the men. This they never do. Single elephants are caught by being bound to trees by men under cover of a couple of tame elephants, the wild one being ignorant of what is going on until he finds himself secured. Escaped elephants are retaken without trouble; even experience does not bring them wisdom. Almost yearly, one or two tame elephants of the hunting establishment at Dacca are lost in the jungles by straying or other accident, while engaged in the capture of their fellows. As an example, in December, 1878, an elephant which had been captured three years, and partially trained to hunting, took fright at the fires and guns used in driving a herd, and ran away. Her mahout fell off, and nothing more was seen of her until March last, when we recaptured her after four and a half years' absence, in a herd of twenty-one elephants, 100 miles from where she was lost. She had a calf at heel. When pricked with a spear and ordered to kneel she did so promptly, and in three days she, and another reclaimed runaway, were employed in the capture of their fellows. While such facts testify to the docility of the elephant, they tell heavily against its intelligence.

Though possessed of a proboscis which is capable of guarding it against such dangers, the wild elephant readily falls into pits dug in its path; while its fellows flee in terror, making no effort to assist the fallen one, as they might easily do by kicking in the earth around the pit. It commonly happens that a young elephant falls into a pit, in which case the mother will remain until the hunters come, without doing anything to assist her offspring, not even feeding it by throwing in a few branches.

In its domesticated state one of the elephant's chief characteristics is, as before stated, its obedience; and it does many things at the slightest hint from its mahout which much impress the onlooker unacquainted with the craft of elephant guidance. The driver's knees are placed behind an elephant's ears as he sits on it, and it is by means of a push, pressure, and other motions that his directions are communicated, as with the pressure of the leg with trained horses in a circus. It would be as reasonable, however, to credit performing dogs which spell out replies to questions with knowing what they are saying, as elephants with appreciating the objects to be gained by much which they do under the direction of their riders.

Then as to the stories regarding the elephant's reasoning powers, what an improbable one is that of the elephant and the tailor, wherein the animal, on being pricked with a needle instead of being fed with sweetmeats as usual, is represented as having gone deliberately to a pond, filled its trunk with dirty water, and returned and squirted it over the tailor and his work! The story accredits the elephant with appreciating the fact that throwing dirty water over his work would be the peculiar manner in which to annoy the tailor! How has he acquired the knowledge of the incongruity of the two things, dirty water and clean linen? He delights in water himself, and would therefore be unlikely to imagine it objectionable to another. If the elephant were possessed of the amount of discernment with which he is commonly credited, is it reasonable to suppose that he would continue to labor for man instead of turning into the nearest jungle? We commonly use elephants to carry provisions for the hunting parties through the same forests wherein they were disporting themselves as wild animals less than a year ago, That they thus submit must be regarded as more creditable to their good dispositions than to their good sense.

All who have had to deal with elephants will agree that their good qualities cannot be exaggerated; that their vices are few and only occur in exceptional animals; that they are neither treacherous nor retentive of an injury; and that they are obedient, gentle, and patient beyond all other domestic animals. But it is no traducement of the elephant to say that it is, in many things, a decidedly stupid animal.

Another matter upon which much misapprehension exists is the height to which elephants grow. We hear and read of Indian elephants 12, 15, even 20 feet high! As a matter of fact, 10 feet in males, and 8 feet 6 inches in females (vertical height at the shoulders, measured as a horse), is very rarely attained, and is not exceeded by one animal in 500. As bearing on this subject, I may quote the following from the "English Cyclopædia." The Mr. Corse referred to therein was a gentleman thoroughly conversant with the Indian elephant. A valuable paper of his on the subject was read before the Royal Society in 1799.

"During the war with Tippoo Sultan, of the 150 elephants under Captain Sandys not one was 10 feet high, and only a few males 9½ feet high. Mr. Corse was very particular in ascertaining the height of the elephants used at Madras, and with the army under Marquis Cornwallis, where there were both Bengal and Ceylon elephants, and he was assured that those of Ceylon were neither higher nor superior to those of Bengal."

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"The Madras elephants have been said to be from 17 to 20 feet high. Now let us see how dimensions shrink before the severity of measurement. Mr. Corse heard from several gentlemen who had been at Dacca that the Nabob there had an elephant 14 feet high. Mr. Corse was desirous to measure him, especially as he had seen the elephant frequently at a former time, and then supposed him to be 12 feet high. He accordingly went to Dacca. At first he sent for the mahout, or driver, who, without hesitation, informed him that the elephant was from 12 to 14 cubits—that is, from 15 to 18 feet high. Mr. Corse measured the elephant exactly, and was rather surprised to find that the animal did not exceed 10 feet in height."

In my own experience, I have had some amusing instances of the difficulty of getting at absolute fact in this matter. I have for some years made a point of ascertaining the height of all the largest elephants I have heard of in India. Five years ago, I inserted a request for information on this subject in all the chief newspapers of India. Accounts of 11 and 12 foot elephants poured in, but none stood the test of inquiry. To make it worth any one's while to establish such dimensions, I offered to give an order upon any gunmaker for the best double barreled rifle and all accessories to any gentleman who could produce evidence of an elephant even 11 feet high. This was never done, and I only found one elephant above 10 feet. This magnificent animal belongs to the Maharajah of Nahun-Sirmoor, in the Punjaub, and measures 10 feet 7¼ inches in vertical height at the withers. I made a journey of 100 miles in a palanquin to measure him with my own hands. He is the only elephant over 10 feet in height that I have ever seen, among many thousands, and he must be regarded as not less phenomenal than a human being of 8 feet.

In connection with this subject, I may mention that twice round an elephant's fore foot is his height within an inch or two; more frequently it is exactly so. Out of many hundreds of elephants of all ages which I have measured, I have only once found the variation to be as much as five inches.

There is, at present, in the Indian Museum in Calcutta, the skeleton of a male Indian elephant which Dr. Anderson, the Superintendent, informed me he thought must have stood about 11¼ feet when alive. But this estimate is based entirely on the height of the skeleton as at present set up, which may be, and in my humble opinion is, too great. I, unfortunately, have not got my note-book, which contains the height of the skeleton, with me in London. The elephant to which this skeleton belonged was shot while wild, and, therefore, could not have been measured when on the ground with any approach to accuracy. It was undoubtedly an exceptionally large animal, but was not over 10 feet, in my opinion, based upon the following consideration: There is now in the British Museum, in South Kensington, a skeleton which I lately brought to England of an elephant which died in June, 1883, at Dacca. I measured this elephant most accurately before his death; his height was 9 feet 10 inches at the shoulder. Now, his femur bone measures over all 3 feet 11¼ inches, and is only an inch shorter than that of the skeleton in the Indian Museum in Calcutta. This seems to me to be a reliable ground of comparison between the two, and to be fatal to the claim advanced for the Calcutta Museum elephant of being 20 inches taller than one with a femur bone only one inch shorter.

In June, 1878, I measured the since famous African elephant Jumbo; he was then 10 ft. 5 in. at the withers, and being about 17 years old, was still growing. I had been unable to ascertain his exact height, measured in the foregoing manner, when he left England for America in 1882. His height was then taken to the top of his back, with his fore and hind feet brought near together. This would tend to arch his back very considerably. He measured 11 ft. 6 in. in this way; but as his forefoot, planted firmly on the ground, measured 5 ft. 6 in., his height at withers was probably about 11 ft. According to Sir Samuel Baker, who has seen large numbers of both Asiatic and African elephants in their native wilds, the Africans, male and female, average about one foot higher than the Asiatic. The case of Jumbo appears to confirm this to a great extent, as regards male elephants; but I have never seen African females even as large as Asiatic females. Of course, in captivity we do not see one African to 1,000 Asiatics (taking India into account), so the comparison is unfavorable to the Africans.

Much misapprehension prevails regarding the uses and powers of the elephant's trunk. This organ is chiefly used by the animal to procure its food, and convey it, and water, to its mouth; also to warn it of danger, by the senses of smell and touch. It is a delicate and sensitive organ, and is never used for rough work. In any dangerous situation, the elephant at once guards it by curling it up. The idea that he can use it for any purpose, from picking up a needle to dragging a piece of ordnance from a bog, is, like many others connected with the elephant, founded entirely upon imagination. An elephant might manage the former feat, though I doubt it (I have never seen elephants raise coins and such small articles otherwise than by suction); the latter he would not attempt. Elephants engaged in such work as dragging timber invariably take the rope between their teeth; they never attempt to pull a heavy weight with the trunk. An elephant is powerful enough to extricate a cannon from a difficult situation, but he does it by pushing with his head or feet, or in harness, never lifting or drawing with the trunk. Elephants do not push with the forehead, or region above the eyes, but with the base of the trunk or snout, about one foot below the eyes.

I may here mention that I have seen many instances of very severe injury to their trunks among wild elephants. These were evidently caused by the sharp edges of split bamboos while the animals were feeding. Some have had from a few inches to a foot of the member totally useless, merely hanging by a little muscle, both nostrils having been cut through.

The age to which the elephant lives is, as must ever be the case with denizens of the forest, uncertain. The general native opinion is that they attain 120 years in exceptional cases (they have been known to reach this age in captivity), but more usually to 80 years. Under the more favorable conditions of a natural life the elephant must attain a much greater age than in captivity. I think it by no means improbable, looking to their peculiar dentition and other circumstances, that elephants live to 150 or 200 years, but this view is, of course, to a great extent a supposition.

One of the most remarkable facts in connection with wild elephants is the extreme rarity of any remains of dead ones being found in the jungles. This circumstance is so marked as to have given rise to the belief among some wild tribes that wild elephants never die; while others believe that there is a place, unseen by human eye, to which they retire to end their days. The latter belief is untenable, as there are no parts of the forests of India that are not well known to, and occasionally visited by, the wild tribes who inhabit them.

In my own wanderings for many years through elephant jungles I have only seen the remains of one female elephant, that had died in giving birth to a calf, and of one elephant drowned in a mountain torrent. Not only have I never seen the remains of an elephant that had died a natural death, but I never met any one among the jungle tribes or professional elephant hunters who had.

Sir Emerson Tennant says in his work on Ceylon: "The natives generally assert that the body of a dead elephant is seldom or never to be discovered in the woods. And certain it is that frequenters of the forest with whom I have conversed, whether European or Singhalese, are consistent in their assurances that they have never found the remains of one elephant that had died a natural death. A European gentleman, who for 36 years without intermission had been living in the jungle, ascending to the summits of mountains in the prosecution of trigonometrical surveys, and penetrating the valleys in tracing roads and opening means of communication—one, too, who has made the habits of wild elephants a subject of constant observation and study—has often expressed to me his astonishment that, after seeing many thousands of living elephants in all possible situations, he had never yet found a single skeleton of a dead one, except those which had fallen by a rifle. The Singhalese have a superstition in relation to the close of life in the elephant; they believe that, on feeling the approach of dissolution, he repairs to a solitary valley, and there resigns himself to death."

This quotation from Sir Emerson Tennant shows the similarity of opinion between the natives of Ceylon and of India. But the belief of a universal sepulcher is untenable on many grounds. It may be believed that, in annually capturing large numbers of elephants, the hunters of the Dacca establishment penetrate the most retired parts of the jungles of Assam, Chittagong, and elsewhere; but although many men have grown gray in the service, I have not met one who has seen a dead elephant's remains, except at a time when an epidemic disease decimated the herds in Chittagong. Jungle fires seldom penetrate the large forests, thus their bones cannot be burned. Monsoon rains do not destroy them for some years, as is proved by the bones of elephants that have been shot, and which may be seen many years later. It may be thought that aged, weak elephants are sometimes unable to extricate themselves from morasses or the soft beds of rivers where they go to take their last drink, and that their remains are swallowed up therein. This possibly may occur occasionally, but there are many elephant jungles where no quicksands or bogs exist. In Mysore, for instance, a province where wild elephants abound, and which I know intimately, the jungle streams are small, and their beds are uniformly rocky. If elephants died in these, their bodies would be floated down through inhabitated country, where they could not escape observation. But this has never, to my knowledge, occurred. It is probable that the longevity of elephants may account to a great extent for their remains rarely being seen. If elephants live for 200 years, the annual deaths from natural causes would only amount to 5 per 1,000. This figure would, no doubt, be exceeded in reality, as elephants are liable to be killed by each other, and to die by various accidents. Though the number that die annually is thus, probably, much less than might be supposed, the mystery of what becomes of the remains of those that do die is still entirely unexplained.

Herds of elephants usually consist of from 30 to 50 individuals, but much larger numbers, even upward of 100, are by no means uncommon. A herd is always led by a female, never by a male. In localities where fodder is scarce, a large herd usually divides into parties of from 10 to 20. These remain at some little distance from each other, but all take part in any common movement, such as a march into another tract of forest. These separate parties are family groups, consisting of old elephants with their children and grandchildren. It thus happens that, though the gregarious instincts of elephants prompt them to form large gatherings, if circumstances necessitate it a herd breaks up under several leaders. Cases frequently occur when they are being hunted; each party will then take measures for its individual safety. It cannot be said that a large herd has any supreme leader. Tuskers never interest themselves in the movement of their herds; they wander much alone, either to visit cultivation where the females, encumbered with young ones, hesitate to follow, or from a love of solitude. Single elephants found wandering in the forests are usually young males, animals debarred from much intimate association with the herds by stronger rivals; but they usually keep within a few miles of their companions. These wandering tuskers are only biding their time until they are able to meet all comers in a herd. The necessity for the females regulating the movements of a herd is evident, as they must accommodate the length and time of their marches, and the localities in which they rest and feed at different hours, to the requirements of their young ones.

Elephant calves usually stand exactly 36 inches at the shoulder when born, and weigh about 200 lb. They live entirely upon milk for five or six months, when they begin to eat tender grass. Their chief support, however, is still milk for some months. I have known three cases of elephants having two calves at a birth. It cannot be said that the female elephant evinces any special attachment to her offspring, while the belief that all the females of a herd show affection for each others' calves is certainly erroneous; were such the case, it would preclude the belief in any marked love for her own young. During the catching of elephants many cases occur in which young ones, after losing their mothers by death or separation, are refused assistance by the other females and are buffeted about as outcasts. When a calf is born, the mother and the herd usually remain in that place for two days. The calf is then capable of marching. Even at this tender age calves are no incumbrance to the herd's movement; the youngest climb hills, and cross rivers, assisted by their dams. In swimming, very young calves are supported by their mothers' trunks, and are held in front of them. When they are a few months old, they scramble on to their mothers' shoulders, and hold on with their forelegs, or they swim alone. Though a few calves are born at other seasons, the largest number make their appearance in September, October, and November.

The elephant is full grown, but is not fully mature, at about 25 years of age. At this period it may be compared to a human being of 18; and it does not attain its full strength and vigor before 35 years. Female elephants give birth to their first calf at from 13 to 16 years of age, when they are still palpably immature themselves. Only the male Indian elephant has tusks; the female is provided with short tushes, or downward prongs, in the upper jaw; they are seldom

more than 4 in. in length. On the continent of India, *mucknas*, or male elephants without tusks, are decidedly rare. The absence of tusks appears to be a mere accidental circumstance. But in Ceylon male elephants with tusks are still more uncommon. Sir Samuel Baker says that not more than 1 in 300 is provided with them. It is difficult to imagine what can cause the vital difference of tusks and no tusks between the elephants of the continent and of Ceylon, as they are of the same species, and the climate and their food may be said to be identical. Elephants occasionally lose one, sometimes both tusks, in accidents in the jungle, and some have only one tusk from birth. The latter are known as *guneshas*, and are reverenced by Hindoos if the tusk retained be the right hand one. Elephants never shed their tusks. Jerdon and others, following Mr. Corse, are undoubtedly in error in saying this occurs between the first and second years of the young elephant's existence or at any other time. The skulls of fœtal elephants exhibit milk tusks, but these never make their appearance; they are absorbed, and the tusk that cuts the gum is the permanent one. Nor are tusks lost by accident ever renewed.

The records of many hundreds of elephants, captured by the Dacca establishment, show that there are about 43 male elephants to 100 females; and one *muckna*, or tuskless male, in every 10 males.

Elephants are exceedingly inoffensive and retiring in their habits. They are very timid in their wild state, and withdraw at once from the intrusion of man. They usually drink after sunrise, and before sunset. They prefer the water of the small tributary streams to that of the larger rivers of the jungles they may be inhabiting; for what reason I have never been able to ascertain. Elephants seldom bathe after the sun is down, except in very warm weather. They swim remarkably well, as is proved by the fact that large numbers are annually sent across the tideway of the combined Ganges and Brambapootra, between Dacca and Barrackpore, and they are sometimes six consecutive hours without touching bottom. I have seen an elephant swim a river 900 yards wide with his hind legs tied together. Elephants are sometimes drowned, apparently by being attacked with cramp, or by a fit.

The only pace of the elephant is the walk, capable of being increased to a fast shuffle of about fifteen miles an hour for a very short distance. The elephant can neither trot, canter, nor gallop, nor can it make the smallest spring either in vertical height or in horizontal distance. A trench 8 ft. wide and 8 ft. deep is quite impassable to an elephant.

It has been satisfactorily settled that there is no such creature as a really white elephant, the so-called albinos of the kings of Burmah and Siam being merely elephants of a somewhat dirty cream color, and in some cases even elephants with only an unusual amount of the flesh-colored blotchings on the face, ears, and neck common in some degree to all elephants. I need not advert here to Mr. Barnum's so-called white elephant further than to say that he is the commonest of common elephants, to be seen every day in India, and does not possess a single peculiarity of any description to justify the statements regarding his color and special character which preceded, and even followed, his arrival in England.

I will now pass to the modes of capturing and training the elephant. Elephants are not bred in captivity in India, as by the time the young ones would be of a useful age, 15 years, they would have cost more than would suffice to capture a number of mature wild ones. Elephants are, however, bred extensively in a semi-wild state in Burmah and in Siam, where fodder is very plentiful. With the exception of such elephants as come from Burmah, almost every elephant seen in India has been wild at one time.

The following are the methods of taking wild elephants: For single elephants, pit-falls; running down and noosing from trained elephants' backs; or tying the animal's legs together under cover of trained females, usually called decoys. When a whole herd is the object of pursuit, a salt-lick, or sometimes a pool in the jungles, is surrounded by a stockade. Men are constantly on the watch, and the gate is closed when a herd has entered. But the most certain plan is that followed by Government, namely, the surrounding a herd, wherever found in the forest, by a large circle of men, and the building a stockade, into which it is driven. This method will be described further on. With regard to the other plans mentioned, the pit-fall is an old native method, and is now prohibited in British territory on account of its cruelty. It may be imagined that an immense majority of the elephants that fell into pits from 15 to 18 feet deep sustained permanent injury, if they were not killed outright, as often happened. The native hunters seldom took the trouble to put bows into the pits to break the force of an elephant's fall. If an elephant was seen to be injured, it was left to die as it fell. I have known four elephants to fall into the same pit together, only of which was got out alive.

The pits were arranged with great ingenuity by the hunters. Sometimes an uncovered one would be left in view, in avoiding which an elephant fell into a covered one alongside. Or several were dug in close proximity, in which others might be taken when fleeing in terror upon the fall of one of their number. Through the carelessness of the hunters, who only visited the pits occasionally, elephants were frequently starved to death before they were discovered.

The plan of inclosing elephants in salt-licks, or places to which elephants in common with all wild animals resort at certain seasons to eat the earth impregnated with soda, used formerly to be much in vogue in Assam. It also led to much cruelty. Natives could seldom procure a sufficient number of tame elephants to deal with a large herd, should one be inclosed; and in former days scores of elephants died in inclosures from want of food during the delay that occurred in sending for tame elephants. Several of these salt-licks are perfect Golgothas to this day. Such reckless waste of elephant life has now, however, been put a stop to.

Running elephants down, and noosing them from the backs of tame elephants, is very rough and dangerous, but highly exciting, sport. It is far from an economical method of taking them, as the wear and tear of the tame elephants is very great. It is conducted as follows: Three or four fast tame elephants are equipped with a rope each, at one end of which there is a noose, the other being secured round their bodies. On some, the noose is on the near side, on others, the off. Each elephant has three riders—the mahout on its neck to guide it; the nooser, kneeling on a small pad on its back, holding the noose in his hands; and a spare man seated behind, whose duty it is to hammer it unmercifully with a spiked mallet. This urges an elephant to a much greater pace than any use of the driver's good will, though that inducement is by no means omitted.

Thus equipped, the elephants approach a herd of wild ones. Sometimes a musket is fired to terrify them, and the chase commences through or over everything, the men saving themselves from being swept off as best they can. Where the ground is favorable, the tame elephants endeavor to range up on opposite sides of a fleeing wild one, of moderate size and strength, when the nooses are cast, and generally encircle its neck. If this is effected, the tame elephants are checked; but the choking of the wild one, or fatal accidents to the tame ones or their riders, by being pulled over, or dragged into ravines, or by being attacked by other elephants, are not unusual accompaniments to this rough work.

Hand-noosing is practiced only in Ceylon, where several hunters on foot manage, with wonderful skill and activity, to noose the hind legs of an elephant when running away, and to secure the trailing ends of the ropes to trees as it passes.

The largest male elephants cannot be captured by the above plans; and from their habit of frequently absenting themselves from their companions, they are seldom caught with the herd by the stockade or kheddah plan. They are the most valuable beasts, and are usually caught in the following manner, or some modification of it: Four or five steady females, ridden by their mahouts, who partly conceal themselves with a dark-colored blanket as they lie on their elephants' necks, are taken to the jungle where the solitary male is known to be, and are there allowed to graze like wild ones, and gradually to approach the male, if he does not take the initiative. Some wild males make off at once, probably scenting the riders, but many abandon themselves without reserve to the society of the females. These keep in constant attendance on the male, sometimes for two days and nights. When the male seems inclined to sleep soundly, usually soon after sunrise, the females stand close around him, and a couple of mahouts on foot tie his hind legs together, and bind him to a tree, if one be near; or they withdraw the tame elephants, and after the male has tired himself out, by dragging his legs after him in his flight, he is fastened to some tree as he passes it. In a day or two cables are got round his neck, and he is marched off.

MODE OF CATCHING WILD ELEPHANTS.

I may here say that the term decoy, often used in reference to elephants engaged in the capture of others, is entirely misleading, as they use no arts to divert the wild ones' attention, as has been constantly asserted, but act entirely at the command of their riders. The statement that one elephant will assist in binding another, except in as far as it will hand up the end of a rope, or pull one when ordered to do so, is entirely incorrect.

The Government kheddah plan is the most certain and economical method of taking wild elephants. As many as 118 have been secured in one drive by this means. A Government hunting party consists of 370 men, trained to the work. They are generally from Chittagong, the natives of that district being unrivaled in the craft. There is a large surplus laboring population in Chittagong, and there is no difficulty in raising one or two kheddah parties during December, January, and February, when there are no agricultural operations on hand. The men receive two and a half months' pay at Rs. 7 (or about 15s.) per mensem, and they also have free rations.

A kheddah party of 370 men having been collected, it marches to the hunting grounds, sometimes 200 miles distant, where a base camp is ready, and where the establishment of tame elephants, generally from 100 to 150, has been collected, together with the stores, tools, and ropes required for the operations. Muskets and rations having been delivered to the men, and religious ceremonies for success having been performed, the hunters enter the jungle. The trackers of the party have probably already marked down a herd, whereupon the hunters approach to within a mile, and then divide under two experienced leaders, one-half filing off to the right, and the other to the left, their object being to inclose the herd in a large circle by meeting beyond it. A man is left at every 30 yards or so along the lines, according to the nature of the ground. The skill with which this movement is effected is very remarkable, as the ground is usually quite unknown to the hunters, and the difficulty of crossing streams and hills, of forcing their way through dense jungle where no path exists, and of gaining the point they are making for without a compass, is considerable.

The circle when completed is often 5 or 6 miles in circumference. A large one, with men posted 50 yards apart or so, is more efficient in keeping in a herd than a smaller one with men much closer. Unless plenty of room be allowed to the elephants, they are liable to break through the cordon of guards; but it is a maxim in elephant catching that, the circle having been once formed, a herd can only escape through accident or great carelessness. It usually takes three or four hours to surround elephants. In a couple of hours the hunters run up a thin fence of split bamboos round the inclosure, and clear a path for communication between each others' posts. Their chief duty then is to see that the elephants do not break out of the circle. The animals seldom give trouble during the day; at night large fires are kept up, and shouts and shots are used to drive them back should they approach. The bamboo fencing serves to show the chief hunters, who patrol the circle at intervals, where the elephants have broken out should they escape, so that the particular men who are to blame can be detected. This investment of the elephants may have to be maintained for a week, sometimes for a month, if the elephants cannot be secured in the first attempts.

The elephants usually give some little trouble for the first two nights, but their conservative nature then seems to lead them to believe that there are set bounds to their wandering; and unless fodder or water becomes scarce, they seldom try to force the guards. A small herd always gives more trouble than a large one. The former may only be a wandering party from some large body of elephants not far away; it then shows a strong desire to break through to join its companions. A small herd, too, probably has no calves with it, which is a great disadvantage, as it is then restless and quick in its movements. And a herd of a dozen elephants or so may be well in command of one courageous leader; whereas, in a large gathering, timid animals preponderate so greatly that a panic is easily established, and elephants that might otherwise behave boldly become infected with the general fear.

One or two of the males of a herd frequently pass in and out of the circle; and I have known several cases in which a portion of a herd has been absent when their companions were surrounded, and has been admitted by the guards by withdrawing at the point where it wished to pass in. Sometimes, but not often, men are killed at their posts by the elephants.

On the day following the investment of the herd, the construction of the kheddah, or small inclosure into which the elephants are to be driven, is commenced. It is situated on one of their chief paths (within the circle), and is constructed with the trunks of young trees, about 6 inches in diameter and 12 feet high, arranged in a circle of from 20 to 50 yards across. Inside, round the foot of the palisades, a trench 6 feet wide and 4 feet deep is dug, the earth from this being thrown up into a bank on the inner side. The trench and bank of loose earth usually deter elephants from attacking the stockade, or should they do so, prevent their employing their full force against it. The palisades are lashed together with canes, and are strongly supported by cross beams and forked supports behind, the whole structure being designed to support outward pressure only. Were elephants to pull the palisades inward, they would yield at once, but they never use their trunks for this purpose. An entrance of 4 yards in width is left for the ingress of the herd, and a gate, studded inside with sharp spikes, is either slung from the trees overhead, or is made in two leaves, and is pushed to upon the entrance of the herd, by men stationed behind it.

A stockade of 40 yards in diameter accommodates 100 elephants easily. To guide the elephants into it, two lines of strong palisades are run out from the gate along each side of the path by which the herd is to approach. These guiding wings diverge to perhaps 60 yards across at their commencement, which may be 100 yards or so from the gate. When the whole is completed, the new woodwork is hidden with leaves and branches. The stockade is usually completed in three or four days. The hunters consider Friday the most lucky day for driving, and they make extraordinary efforts to get the stockade ready by that day if possible. The work of the stockade is done by one-half the hunters being taken from the large circle from morning till evening, daily, as a weak cordon of guards suffices to keep the elephants in during the day.

All being in readiness for driving, a number of men are taken from the original circle, and a smaller interior surround is formed by commencing at the guiding wings of the kheddah, and posting the men until the elephants are again closed. The original circle is, of course, still maintained, in case of the elephants breaking through the inner one. If the herd be in two or three detachments, as frequently happens, these are quietly driven together, and the whole are then moved forward toward the kheddah. Should they show an inclination to break to the right or left, the men deter them by striking their axes against the trees. When the elephants gain the funnel-shaped approach to the stockade, the men close in from behind, and from the sides, and urge them on with shots and shouts. If the herd suspects danger, and breaks back through the beaters, fatal accidents not uncommonly occur. Sometimes a herd declines altogether to go in the direction of the stockade, owing to their having the wind from that quarter. In such a case a new stockade may have to be constructed, and if that does not succeed, others also. In this way elephants are sometimes kept in a surround for a month.

Supposing the herd to have been got within the wings near the gate, a line of dry grass and bamboos arranged beforehand is fired, and their retreat is cut off. They then sometimes attack the guiding palisades, but men with spears and muskets receive them here. I have seen two cases in which the elephants forced the palisades and killed men behind them. Tame elephants are used, if possible, to assist at this stage of driving, chiefly as a protection to the men on foot, who run behind them should any elephant turn and charge. There is much less danger of this occurring in dealing with large herds than with small ones, as should a single elephant charge out of a large herd, it is rarely supported, and it quickly rejoins its companions. But a determined leader of a handful of elephants is liable to be followed at once by the rest. When an elephant chases the men, they betake themselves to the shelter of tree trunks, bamboo clumps, or long grass, and it is astonishing how they frequently escape uninjured. I have known many cases of men standing against a tree, or hiding in tufts of long grass, within a couple of yards of elephants that were pausing in indecision, without being discovered, though the elephants were evidently aware of their close proximity, as they kicked up the ground in anger, and then made off. In such cases the slightest movement would have led to the hunters being instantly trampled to death. Men are frequently killed, of course, but they are almost always young hands who are learning. I saw one such make a narrow escape a few years ago; he ran from an elephant and climbed a tree; the elephant butted the trunk and the man fell down, but his pursuer was so astonished at the sight that she fled at once.

Sometimes drives are conducted by torchlight, and these seldom fail, owing to the elephant's fear of fire. The scenes on these occasions are exciting beyond description. The elephants in rushing along tear down large branches of trees that are connected with the undergrowth by climbing plants, and even sometimes upset dry trees bodily in their passage. The cries of the young, and the deep, thunder-like growls of the elders of the herd, the continued crashing of the jungle, and the shots and incessant cries of the men, form, with the unnatural light of the fires and of torches moving through the forest paths, a scene that cannot fade from the memory of any one who has witnessed it.

When a herd has been driven into the stockade, the gate is closed and barricaded, and men with firebrands and spears repel any attacks upon it or the palisades. But the trench is usually sufficient to deter the elephants from crossing it. On the same or following day, ten or twelve tame elephants are admitted with a mahout and rope tier upon each, and it is a very remarkable fact that the wild ones very rarely attempt to dislodge the riders, as they easily might. They naturally fail to comprehend anything so foreign to their experience as a man upon an elephant's back. I never knew a case, except one that happened to myself, of any rider being attacked by a wild elephant. The mahouts separate the wild elephants one by one from their companions, when their hind legs are tied by men who slip to the ground for the purpose. A rope is then secured round each captive's neck, and to its hind legs, and it is led out and picketed in the forest near.

If two well matched rival tuskers happen to be impounded in one stockade, they sometimes fight to the death, seemingly regardless of their novel position. If not well matched, the more powerful one bullies the weaker one incessantly. On one occasion, when a herd of forty-eight elephants had been impounded, a scene of this kind occurred, one elephant following and fighting with another almost continuously for two days and nights. The smaller elephant retaliated on others weaker than himself, and between them the pair killed four young elephants and a large *muckna*. They caused such commotion that the tame elephants could not be admitted. At last the larger tusker forced the smaller one across the trench, and against the palisades. The latter commenced to break his way out; and though muskets were fired into his face, and spears and digging tools, made red hot for the occasion, were applied to his trunk and head, the inducement behind was so strong that the counter efforts of the men were unavailing, and he made his way

through the palisade, and went off into the jungle. This was at 2 A.M., and was a sufficiently exciting scene. No other elephants attempted to follow, and the gap was quickly repaired.

Among these forty-eight elephants was one that had escaped about twelve years ago, judging from the ages of her three calves. We first observed the fact of her being an escaped elephant by seeing old rope marks on her legs. When the tame elephants entered the stockade, two ranged alongside this one, and on being pricked with a spear, and told to kneel, she obeyed at once. She was ridden alone a few days afterward.

The number of wild elephants that can be taken care of is, at the most, 50 per cent. more than the tame ones. As each capture is concluded, the wild elephants are marched out of the jungle into open country, for if kept in the forest they continue to be excited by jungle sights and sounds, and to struggle for liberty, while flies are much more troublesome to their wounds in the jungle than in the plains. Each batch of new elephants requires a number of tame ones to be detached in charge of it; thus the hunting operations are limited by the number of the latter.

When a sufficient number of elephants has been taken, the hunters are dismissed, and all elephants under 7 ft. in height are sold to merchants who follow the kheddah parties for the purpose of purchasing such. Those above 7 ft. are retained for Government service, except some males and old females, which are also disposed of. Not more than 30 per cent. of the elephants captured are young and strong females, thoroughly suitable for Government service. The selected wild elephants are now divided into gangs of twenties, with a proportion of tame ones in charge. These escort the wild ones, bring their fodder, and lead them to water daily. The march from the jungle commences about the end of February, and the elephants reach the depot at Dacca in May. They are then put into training, and by November are quite steady, and are drafted for military service.

HOW ELEPHANTS ARE TRAINED.

New elephants are trained as follows: They are first tied between two trees, and are rubbed down by a number of men with long bamboos, to an accompaniment of the most extravagant eulogies of the animal, sung and shouted at it at the top of their voices. The animal, of course, lashes out furiously at first; but in a few days it ceases to act on the offensive, or, as natives say, "*Shurum lugta hai*," ("It becomes ashamed of itself"), and it then stands with its trunk curled up, shrinking from the men. Ropes are now tied round its body, and it is mounted at its picket for several days. It is then taken out for exercise, secured between two tame elephants. The ropes still remain round its body to enable the mahout to hold on should the elephant try to shake him off. A man precedes it with a spear to teach it to halt when ordered to do so; while as the tame elephants wheel to the right or left the mahout presses its neck with his knees, and taps it on the head with a small stick, to train it to turn in the required direction. To teach an elephant to kneel, it is taken into water five feet deep when the sun is hot, and upon being pricked on the back with a pointed stick it soon lies down, partly to avoid the pain, partly from inclination for a bath. By taking it into shallow water daily, it is soon taught to kneel even on land.

Elephants are taught to pick up anything from the ground by a rope, with a piece of wood attached, being dangled over their foreheads, near to the ground. The wood strikes against their trunk and forefeet, and to avoid the discomfort the elephant soon takes it in his trunk, and carries it. It eventually learns to do this without a rope being attached to the object.

I have only time to add a few facts regarding the financial results of elephant catching by the Government establishment at Dacca. Referring only to the official year ended 31st March, 1883, the expenditure upon the hunting establishment for twelve months was £12,948,* and the receipts by surplus elephants sold, and the value of those retained, £19,492, showing a profit of £6,544. Of this amount, £4,000 was surplus from the preceding year.

During the past five years the annual average number of elephants captured during our short working season, from December to February, has been 154. The greatest number in any single year was 252 in seven weeks in 1882, and 199 in a similar period in 1883. A ready sale is effected among the native landowners, and others who are fond of keeping elephants, of all those not required by Government.

The belief that wild elephants have decreased in India is not an uncommon one, and may have arisen from the fact of laws having been passed in late years for their protection. Also from their undoubted decrease some years ago in Ceylon. But the case of that island is not analogous to that of the continent. In Ceylon, elephants have always been made a peculiar object of pursuit by large numbers of sportsmen, and by paid native hunters, while their range is not without its limits. To show the numbers that have been destroyed there, I may quote the official statistics between 1845 and 1859, which show that during those fifteen years rewards were paid for 5,194 elephants killed in, I believe, only a part of the island. Similar destruction has gone on for years, until rewards were abolished some years ago. But elephants are again becoming numerous, and are again allowed to be shot.

But on the continent of India the number shot by European sportsmen has always been small, and it was only for a few years that natives were induced to turn their attention to killing them by a reward given for their destruction in the Madras Presidency. This was soon withdrawn, and the representations of humane officials having further led to the curtailment of the wasteful methods of trapping them practiced by native hunters, the wild elephant now enjoys perfect immunity throughout the Western Ghats, and those boundless forests extending for hundreds of miles along the foot of the Himalayas into Burmah and Siam. The number annually caught by the Government hunting establishment at Dacca (the only one at present in India), and by licensed native hunters, is, comparatively speaking, very small; and there is no doubt that all the forest ground that can be legitimately allowed to the wild elephant is as fully occupied at present as is desirable. The elephant-catching records of the past fifty years attest the fact that there is no diminution in the numbers now obtained in Bengal, while in Southern India elephants have become so numerous of late years that they are annually appearing in places where they had never been heard of before.

In the Billigarungun Hills, an isolated range of 300 square miles on the borders of Mysore, wild elephants first made their appearance about the beginning of this century, having strayed from the forests at the foot of the Neilgherry range, across an intervening strip of some thirty miles of civilized country. Prior to that time the Sholagas, a wild tribe that inhabit the Billigarungun Hills, but which has now dwindled down to a handful of savages, were a numerous people; traces of their former extensive cultivation, even of orange groves, gardens, and iron-smelting furnaces, still exist, together with lakes on the summit of the hills, for the convenience of the cattle which used to be driven thither from the neighboring low country for pasturage during the hot weather. The Sholagas were almost destroyed by three successive visitations of small-pox, a disease which is always exceedingly fatal among hill people in India; their lands relapsed into the densest forest; and wild elephants and bison now abound where probably not one was to be found a century ago. The case of these hills is an interesting instance of a large tract of country in India having relapsed into a wilderness in recent times.

To give an idea of the numbers of wild elephants in some forests, I may say that during the past five years, between 1878 and 1883, 1,066 wild elephants have been captured by the Dacca hunting establishment in a tract of country about fifty miles long by twenty miles broad, in the Garo hills in Assam, while fully as many more were met with during the hunting operations. Of course these elephants do not confine themselves to that tract alone, but wander into other parts of the hills. There are immense tracts of forest in India similarly well stocked with wild elephants.

I am sure it will be regarded as a matter for hearty congratulation by all, that so grand, interesting, useful, and harmless an animal as is the elephant is in no danger of becoming extinct in India. Though small portions of its haunts have been cleared for tea or coffee cultivation, the present forest area of the country will, probably, never be practically reduced, for reasons connected with the timber supply and climate; and as long as its haunts remain, the elephant must flourish under due regulations for its protection.

* Taking the rupee at 2s., for convenience.

MICROSCOPICAL LIVE BOX FOR FISH.*

MR. STOKES recently exhibited and described a simple apparatus for aerating living fish while under microscopical observation.

This apparatus is shown in perspective view at Fig. 2, Fig. 3 being a longitudinal section. In these figures, *a a* are two

Fig 2.

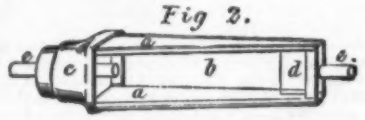


Fig 3

wedge-shaped slips of wood, well soaked in paraffine wax to render them water proof; *b b* are two 3 by 1 glass slips, which are so arranged as to form with the wood slips a wedge-shaped glass box.

The larger end of this box is inclosed in a short piece of India rubber tube, *c*, and this tube is closed by a cork.

A short piece of glass, *d*, is fixed inside, about midway between the glass sides of the box, so that it will form a shelf upon which the fish's tail may lie during examination, as shown in Fig. 3.

At either end of the box are fitted two short glass tubes, *e e*, which, when the instrument is in use, are respectively connected by India rubber pipes with two bottles. One of these bottles is to be placed on the table below the level of the microscope stage, and the other—filled with water—a little above the level of the other. The water will then pass from the upper bottle through the wedge-shaped box into the lower bottle, and when the latter is full the position of the bottles may be reversed, and in this way a constant circulation kept up for any length of time.

The diaphragm at *d* is a little nearer to one side than to the other, so as to allow for different sized tails on either side, and yet to keep them close to the upper glass.

The tube, *e*, can be pushed through the cork any distance, thus forcing the fish toward the apex of the wedge.

The apparatus is made especially for minnows or sticklebacks. The circulation of the blood of the tail and fins, the growth of fungus on the skin, the habits of such parasites as the *Argulus foliaceus*—all may be watched by the hour together.

Minnows are cheap; every microscopist possesses the materials for making the apparatus himself. Should any reader be too busy to make the affair, he can obtain it ready made of Mr. Stanley, optician, Railway Approach, London Bridge.

* *Journal* of Quekett Club, Feb., 1884.

SHOW BEDS OF HYACINTHS.

IN his *Florists' Directory* (1792) John Maddock begins his introduction with the following words: "The finer flowers more particularly demanding our attention are the hyacinth, the tulip, the ranunculus, the anemone, the auricula, the carnation, the pink, and the polyanthus." This was the general opinion of the florists of the former century; so, for example, George Voorhelm, in his *Treatise on the Hyacinth* (the English edition was published in 1758), names as the favorites of the day the hyacinth, the tulip, the auricula, the carnation, the ranunculus, and the anemone. In the course of time many other flowers have become favorites for a shorter or longer period; some of the old flowers have been temporarily neglected, but with all these variations of taste the bulb growers of Haarlem and its vicinity have kept in honor the old fashioned flowers, and yet at this moment their register is at least partially the same as it was in Voorhelm and Maddock's time, a century ago and before. At that time they say: "The fine flowers more particularly demanding our attention are the hyacinth and the tulip." The fact that these flowers, being among the oldest introduced into European flower gardens, are always in fashion, and that their culture on an extensive scale is possible, gives the best proof how, by the exertions of the Dutch growers, these plants have been perpetuated in the lapse of time, so that in spite of the crowning of so many other new fine and elegant florists' flowers which have been introduced and cultivated since, they still form objects of interest and trade.

Although the way to treat these plants has taken in many instances a different direction from that which used to be the case in the eighteenth century, there are some good things which, temporarily neglected, are again found acceptable. We often return to what our forefathers have admired, so it has been the case with the parade beds of hyacinths, of which we subjoin a figure. We find them already described by Maddock, and previously by George Voorhelm and the Marquis de Saint Simon, in 1768. They were at that time more moderately arranged than at present, but the general system was the same as nowadays. In Holland such parade beds were popular, and in the first part of the present century they were found in every first-rate nursery at Haarlem. The last firm who used to plant them anually was that of Messrs. Krelage, who used to do so perhaps twenty years ago. Then the spring shows in Holland, where large collections of hyacinths were required, gave another direction to the taste, and caused the temporary abandonment of parade beds. Five years ago some bulb growers combined to again arrange such a parade bed, and Mr Krelage at the same time opened his beds at the Kleine Houtrey. This was in 1880, and since that time the parade beds have been planted and admired every year. They are covered when in bloom by a large tent, which is in the middle about 14 feet high, at the sides 8 feet, and at the ground 32 feet wide. The length of the tent is 82 feet, that of the entrance pavilion 14 feet—together 96 feet. The length of the beds wherein the hyacinths are planted in October is 50 feet; they are 4 feet broad, and about six inches above the level of the ground. Wooden frames are placed around the beds, 1 foot high, which can be made higher if necessary by a second frame of five inches high. The back part of these frames remains to give a good background for the examination of the hyacinths. When the beds are in bloom the covering of the tent is rolled up during the night, and then the frames are put around the beds, and covered with mats.

In each bed there are planted 102 rows of hyacinths, six bulbs in each row, in the former bed planted only with single blooming sorts of the medium season. In every row only one variety is planted, and the arrangement is such that, when in flower, the back rows show above the front ones, and that the whole bed forms a regular curved line, of which the highest point is in the middle. The succesion of color in the arrangement is red, white, and blue, but among the reds are found all gradations of that color, as well as the shades of violet, mauve, and purple. With the whites are found the rosy whites, yellows, and orange; and with the blues all the shades of that color, from the lightest lilac to the darkest black. It is quite obvious that this row bed, as it ought to be called, by translating the Dutch term, makes a splendid effect, and is the admiration of every visitor, especially as the plants are carefully arranged so as to flower all at the same time.

The other bed, which may be called the dressed bed—again using the expression popular in Holland—is more the delight

SHOW BEDS OF HYACINTHS AT HAARLEM.

of the true *connoisseur*. Here the same number of bulbs is planted, but in pairs of the same variety, one next to the other, so that in the two neighboring rows there are twelve plants in six varieties. Also here the same succession of colors is observed as in the other bed; but, by a different arrangement, the double lines of red, white, and blue show themselves in a sloping direction, as is well represented in the figure. In this bed are planted the latter single varieties as well as the best double ones. This bed is equally interesting, because here are to be found, besides many novelties of the establishment not yet in the trade, all those new sorts which have been lately introduced for the first time, and others for trial, as far as it can be expected that they will do honor to the collections.

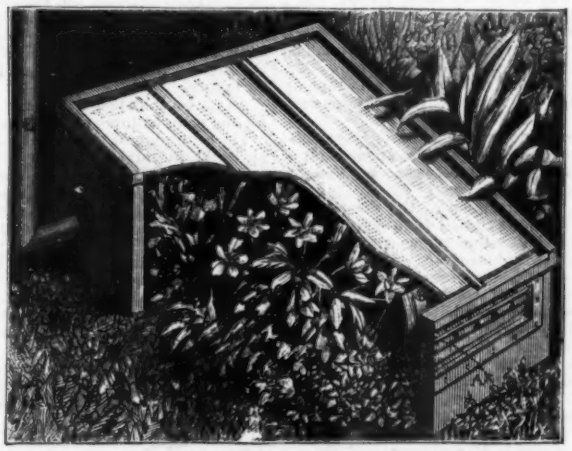
As in general no variety is planted twice in the beds, and the row bed containing all varieties different from those in those in the other, visitors can see in these beds at once about 400 of the best varieties known, among them many at present not in general cultivation of such merits as will insure them becoming favorites in future times. It is an extended field for study for the large number of hyacinth growers of the neighborhood of Haarlem, who, as well as the amateurs of fine flowers in general, visit regularly this flower show at the time it is opened, which is for foreigners every day from 10 to 12 o'clock in the forenoon, and from 2 to 4 o'clock in the afternoon. This year the show, which is usually somewhat later than the general flowering in the open fields, will be opened during the whole month of April, and the best period for visiting it will probably be between April 6 and 20. For those who visit Holland this month it will be well worth while to pay a visit to these beds. A catalogue is published and obtainable by the visitors, giving the names of the hyacinths planted in the beds, with the numbers, so as easily to find that of every variety. Such parade beds of hyacinths are to be found in no other establishment, and the whole arrangement is more splendid than has been seen before under similar circumstances.—*The Gardeners' Chronicle.*

AN IMPROVED GARDEN FRAME.

IN a closed frame the plants under glass are incapable of supporting the direct action of the sun's light and heat, provided it be intense and prolonged, without injury and without running a risk of perishing. The leaves wither and the flower stalks droop, since the equilibrium is broken between the transpiration (which becomes excessive) and the aeration, that becomes insufficient, owing to the fact that the air belated frame, the plants do not experience any bad effect from the solar radiation. This fact is explained by the interposition, between the sash and the plants, of layers of air whose renewal is quickened by reason of the heat produced under the glass. The external air, flowing and spreading out under the sash, forms a sort of transparent protecting screen, and, through the heat transmitted to it by the glass, dilates in such a way as to descend with an imperceptible velocity that does not disturb the plants. And yet, upon its exit from the chimney, the warm current of air is appreciable to the hand.

When the sun ceases to heat the frame there is no longer any draught, and consequently no entrance of cold air. It would be an error, however, to think that the apparatus operates only when the sun is shining. It is easy to convince ourselves of the action of the light diffused in the ventilated frame. In fact, if a thermometer be placed in the latter, and another one outside of it, the least variations in the solar light will be read upon the thermometer under glass, and be marked by a sensitiveness that the external instrument does not show.

No one is ignorant of the fact that, during the winter months especially, the ventilating of plants under glass presents great difficulties. The apparatus under consideration obviates these. The gardener, relieved from the care of shading, uncovering, and opening the apparatus, has nothing to do but leave it to itself. He has nothing to fear from those excesses of air or heat that are so fatal to plants cultivated under glass, since the apparatus itself assumes the care of guarding against their injurious effects without in any way depriving them of their beneficial ones.—*La Nature.*



DUMESNIL AND REYNIER'S IMPROVED GARDEN FRAME.

comes dry and is not renewed. This same thing occurs, moreover, in the open air in summer upon the approach of storms, when the air becomes dry through a burning sun.

For this reason, gardeners shade their frames with curtains or blinds, whitewash the panes of glass so as to diminish the too intense action of the light, or else raise the sash so as to diminish the heat and renew the air. But in either case, there is a loss of light or of heat which does not benefit the plants; and, moreover, when the sash is raised, the external air, entering the heated frame with more or less violence, becomes injurious to them.

If we could find a method of introducing under the heated sashes of the frame a current of air which should become cool before touching the plants, and the renewal of which could be proportioned to the heat produced under the glass, the plants would not wither and would profit by all the light, as well as by all the solar heat, which latter, when the sun is shining, is, under glass, at least, double or at times triple what it is outside. The gardener would then no longer have to take any precautions, since the air, light, and heat would be in equilibrium. Such a thing has just been realized by Messrs. Dumesnil & Reynier in the construction of a very simple apparatus.

For the sake of example, we represent herewith the application of the system to a garden frame.

In the front of the frame, and over a length of about 60 centimeters, starting from one of the extremities, there is a series of apertures, A, that may be easily stopped up with corks when a partial regulation is desired, or that may all be entirely closed at one and the same time by means of a slide. In the interior there is fixed a thin linen screen, B, which corresponds to the apertures, A, and which is so arranged as to allow of a space of but about two centimeters between its upper edge and the glass. Near one of the corners of the opposite extremity of the frame there is fixed a galvanized sheet iron chimney, E, about six centimeters in diameter and one meter in height, and capable of being closed at its upper part.

If the frame be exposed to the rays of the sun, and be tightly closed, only the chimney and the apertures, A, being open, the panes of glass will transmit the heat they receive from the sun to the immediately subjacent stratum of air, and this latter, becoming heated, will rise along the sash up to the upper part of the frame, where, being driven on by new strata of hot air, it will descend and then flow up the chimney, thus producing a draught. This draught will cause the entrance of more external air, which, following the screen, will impinge against the glass and become heated before distributing itself throughout the frame. At the moment of the strongest draught, when the sun is directly striking the venti-

AGES AT WHICH TREES TRANSPLANT BEST.

WHERE large trees or shrubs are transplanted, it is generally either with the object of giving them a better position or of producing an effect at once; generally the last. When the object is to furnish the landscape around a mansion, perhaps newly erected, it is a good plan to plant at least a portion of the ground with trees of as large a size as can be procured and transplanted safely; but otherwise, except in isolated and exceptional cases, it is better to begin with young trees. It is a well ascertained fact that trees raised from seed where they are to grow make the tallest and finest specimens; but, for several reasons, this plan is not generally practicable now in this country, and small plants from the nursery are generally employed. It often becomes necessary, however, to thin out shrubberies and plantations in gardens and on estates, and the thinnings present a ready means of extending these in other directions; and if transplanted carefully, they grow and do well. It would be difficult to say at what age such subjects as chestnuts, beeches, oaks, elms, planes, thorns, spruces, and firs, etc., may not be moved with success up to thirty years of age, so much depends upon circumstances; but it is seldom wise to leave trees intended to be transplanted till they reach that age, because they get drawn up weakly by being so long crowded. The larger the trees, the greater the difficulty, no matter what their age may be. In warm situations and in good deep soils, the tops soon grow large and the roots extend, and hence both are most difficult to carry away. With proper transplanting machines and care, of course, almost any tree may be transplanted; but transplanting operations on a large scale are too often carried on with rough and ready appliances. I have seen many hundreds of trees moved within the past fifteen years, and very few of them failed altogether, though none were under fifteen years of age, and many would be more; but in all cases the common spruce suffered worst, while *Pinus austriaca* and the Scotch fir seemed to endure considerable hardships and yet thrive. Both I have seen moved during severe frosts at midwinter and grow, but not all. In mild weather both may be moved at any time, provided a good bit of soil is attached to the roots.

Deciduous trees will transplant successfully as long as they are growing vigorously, and while they are not too heavy or tall to carry from one place to another, provided they are moved at the proper time and with as many roots and fibers as possible; with them a ball of soil is not of so much consequence. However, moderate sized trees are best, as they need less staying, and are not so liable to be prostrated or shaken by wind. I once lifted fifty vigorous apple trees, none of them less than forty years of age, probably. They had not been disturbed at the root for many years; consequently the roots were all strong and fiberless, and had no soil to them. The result was that none of the trees put forth a leaf the following season, and made very feeble growth the second year; but they eventually recovered and did well. With evergreen trees and shrubs like the holly, yew, laurel, etc., it is different. I have transplanted these of all ages, up to about forty years, on many occasions during the past eighteen years, the object of moving the large specimens being to fill up gaps; but if I had to do the same work over again, I would prefer young trees from five to ten years of age. Very few hollies died outright, thanks principally to the fact of their being moved at the right season—May or August; but numbers of them received such a severe shock in the moving that they have hardly added a foot to their stature in ten years or more. When a holly tree dies from transplanting, its leaves soon wither, but hang on the tree; when it lives, it probably casts more less or of its foliage, and not unfrequently the whole of it, leaving the branches quite naked, but not dead, except perhaps at the extremities. Still, in such cases, it is years before the tree is fairly clothed with fresh foliage, while no growth is made, and in the end it is often necessary to cut all the branches back considerably in order to induce a fresh and stronger break from the old wood, thus greatly reducing the size of the tree, which is overtaken and surpassed by younger and smaller trees put in at the same time. Undoubtedly the best way to have a good holly fence, be it high or low, is to begin with young trees in good health. It is the same with yews and laurels, especially the latter, which, if moved when a good few years old, soon age or grow feeble at the top. When the branches are well cut back at the same time, however, laurels grow well enough, if in good health to begin with; but cutting the branches defeats the object of the planter of large bushes. Pruning of evergreens recently transplanted should always be deferred till April, or even later. So long as growth has not commenced, nothing is lost; something is rather gained, for wounds soonest heal over when growth follows soon after pruning. Many a large evergreen is killed or injured by being cut too severely back.

As regards the best season for transplanting, deciduous trees may be moved at any season between leaf-falling and bud-bursting in spring; but October and November are the best months, and from February till April or May the next best. I have moved elms, planes, and horse chestnuts, etc., on an emergency after they had come well into leaf, and without injury, taking care to water well for some time after planting. Deciduous trees, planted at the right time do not need much watering. Evergreens should be planted at the same season as deciduous trees, with the exception of hollies and some of the more delicate fir tribe, both of which should be transplanted in August or September, or late in spring, at least in the case of large trees.

At whatever age or season trees are transplanted, success depends largely upon the manner in which the operation of raising the roots of the tree is performed. Some people think if they get a good ball of soil away with the root, it is enough; but it all depends where the roots are. Trees that produce a bunch of roots like a box tree will move with a small ball, because all the roots are near to the stem; but in the great majority of trees the roots spread out a considerable distance, and mostly all the fibrous or feeding roots are at the extremities; and hence these must be preserved carefully. The object of having soil to the roots is simply to preserve the small rootlets, and if these could be had without the soil it would answer almost as well; only many roots are necessarily lost in digging the soil away in the transplanting. On large estates, where a nursery is provided, many trees of a few special kinds may be kept for filling up blanks; and if they are annually or periodically root-pruned or dug round, they will lift without much check or injury.—*S. W., The Garden.*

AN OAK IN A GLASS OF WATER.

HOW TO GROW AN OAK IN A GLASS OF WATER.

TAKE an acorn, pass a strong wire through it, and suspend it (as shown in the cut) in a glass of water in such a way that it shall not touch the liquid. After a little while a root will put forth and descend into the water, and later on the upper part of the acorn will open and a little stalk provided with two delicate leaves will make its appearance and continue to grow all summer. In the fall the little sapling may be planted in the ground.—*Science et Nature.*

ANCIENT COPPER IMPLEMENTS FROM MEXICO.

CONSIDERABLE interest has been felt of late in the discussion of the question as to what extent bronze implements had been used in North America before the arrival of Europeans. It seems now pretty well conceded that copper implements found within the limits of the United States are of hammered copper, without any admixture of tin, and probably made from native metal such as occurs so plentifully at Lake Superior. The result of recent investigations into the copper implements of Mexico have been embodied in an address of F. W. Putnam before the American Antiquarian Society. Cortez records the fact that the Mexicans used copper, tin, gold, and silver, and that he obtained enough of the two former to make bronze cannon. He has also stated that the Mexicans were well acquainted with bronze.

Mr. Putnam seems to admit that the Mexicans smelted copper and tin ores, and doubtless formed bronze objects. But the question is a difficult one to determine experimentally, as nearly all of the copper objects of Mexico, along with their articles of gold and silver, have disappeared in the melting pot, and to-day copper implements in Mexico are found but seldom, and collections of such objects receive exceptional attention. A find of a number near Tlacolula

Oaxaca has afforded Mr. Putnam an opportunity to describe a few. They are hammers and hoes, the former predominating, varying in length from 4 to 6 inches, and in width from 2 to 6 inches. They are rusted and incrusted with carbonate of copper as found, and appear to have been hammered out from blocks 5 inches in length, produced in smelting the copper ores. They are, in general outline, shanks 3 to 5 inches long, tapering slightly to the edge of attachment to their wooden handles, which is also the thickest, and widening at the opposite extremity into rounded blades or T-shaped flukes. The T-shaped objects are considered to have served the purpose of hoes. It is presumed that one of these latter tools was cut from a sheet of copper "about a sixteenth of an inch thick."

In addition to the above named objects, three others with semi-lunar expansions were described by Mr. Putnam with a more triangular outline and narrower, straighter arms. These were regarded by Dr. Valentini as knives to be fitted by their shanks into wooden handles, but Mr. Putnam considers them to correspond to the copper implements found in Peru called "trowels," which were employed to smooth soft surfaces of clay vessels. Others have regarded them as coins or tribute money.

NOTES UPON GEOLOGICAL EXPLORATIONS AND SURVEYS IN THE FAR WEST.

By L. P. GRATACAP.

I.

THE western regions of our country, up to 1800, were almost a *terra incognita*, and except for the occasional tales of hunters, traders, soldiers, and adventurers, they remained to the general mind inchoate, vast, and boundless. The United States had not then acquired territorial rights to all the land beyond the Mississippi, as the French domain, succeeding the Spanish possession, embraced the ill-defined country known as Louisiana, which extended westward from the great river to the eastern limits of New Spain, which was yet governed by the arms and yielded allegiance to the flag of Castile.

A few sporadic attempts at exploration in this almost limitless area were made early in this century and at the end of the last. Among these may be recalled that of Du Pratz, a Frenchman, who made an extended journey over Louisiana, and his work was really the first important contribution toward a geographical knowledge of this region. Lieutenant Pike explored, in 1805, the upper Mississippi to its junction with the Missouri, fixing its course with commendable accuracy. In a second expedition he examined the districts of Louisiana south of Missouri. He ascended the Great Osage River, then descended toward the Arkansas, searched its source, discovered the sources of the Red River, and, becoming bewildered in the snowy regions at the head of the Arkansas, went too far westward and struck the Great Rio del Norte, when he was arrested within the boundaries of the Spanish provinces.

Lieutenant Wilkinson, who separated from Lieutenant Pike on the Arkansas, published an account of the lower portion of this river, and his charts supplied excellent materials for subsequent maps.

In 1806-07, Dr. Hunter and Mr. Dunbar traced a few of the Western rivers, ascended the Washita River, which runs into the Red River some miles above the latter's junction with the Mississippi, and Dr. Sibley obtained a large amount of information about the Red River from a respectable native trader. This account, together with Mr. Dunbar's and Dr. Huntley's description of Washita, were transmitted to the President, who communicated them to Congress in 1806, and they were afterward published by the Government.

In the latter part of the eighteenth century, John Ledyard, at the instigation of Thomas Jefferson, afterward President, proposed to cross Siberia and Kamschatka, in Asia, land on our western shores, and passing inland, reach the Missouri, and so follow its waters until he reached civilization. This bold scheme was frustrated by the Empress of Russia, who at the last moment seized the amazed Ledyard, after he had pursued a long journey in her empire, and transported him to Poland, where he was abandoned. Again, in 1792, it was proposed to the American Philosophical Society to dispatch some competent person to explore the far West. Captain Lewis and a French botanist appointed by the French Government formed a union for this object, and had started for their point of departure, when the botanist, M. Andre Michaux, was recalled, and the exploit relinquished.

In the summer of 1803 was inaugurated the first expedition which attracted widespread attention, and which was seconded by the aid and sympathy of the National Government. Thus was the famous expedition initiated by Thomas Jefferson and commanded by Captains Lewis and Clarke, whose memorable explorations form one of the most fascinating incidents of American travel.

It originated in a desire on the part of Congress to extend the trading facilities of American agents with the Indians of the Missouri, and to meditately secure a better knowledge of that vast western area which was so certainly destined to become absorbed in the new republic, and of which a large portion—Louisiana—had then become ours by treaty with the French.

The directions given to Capt. Lewis embraced a number of instructive points, which covered principally the following subjects: He was to explore the Missouri and its principal tributaries, and crossing the continental watershed of the Rocky Mountains descend by the Columbia, or any other river, to the Pacific coast, noting the latitude and longitude of the salient points and the course of the rivers; he was to carefully examine the Indian nations he encountered in almost every detail imaginable; he was to study the zoology, geology, and economic character of the lands he crossed, and the physical features and meteorology were not to escape record. It may safely be presumed that nothing short of an organized corps of trained observers with plenty of time was needed for this exhaustive work, and this Capt. Lewis did not have.

But these functions were cheerfully assumed and well discharged by Capt. Lewis. He did not edit his own journal, as his sad death frustrated his designs in that regard. The objects of natural history and vocabularies were intrusted to Prof. Barton. Paul Allen was the final editor of Capt. Lewis' journal, which was printed in 1814, at Philadelphia, and more sumptuously in London, by Longman, Hunt, Rees, Orme & Brown. Capt. Clarke and two sergeants who kept diaries, and Mr. George Shannon, supplemented Capt. Lewis' manuscript with their personal observations.

Lewis and Clarke ascended the Missouri to its source, crossed the Rocky Mountains by the Lewis and Clarke pass, south of Pass Marias, and descended the Columbia to the Pacific. In 1804, May 14, they entered the Missouri, and in November wintered with the Mandan Indians, having proceeded 1,609 miles. They resumed their journey April, 1805, and on August 18 reached the extreme navigable part of the Missouri, upward of 3,000 miles from its mouth.

They crossed the Rockies, descended the Columbia, and reached the Pacific on November 15, and wintered there. On the 27th of March they set out to return, and reached St. Louis on the 23d of September, having traveled nearly 9,000 miles. The map which was drawn of the western country north of latitude 40° N. from their observations is very interesting. It can be found in the quarto edition of their travels published by Longman & Co., London, 1814.

In 1806 the Red River of the South was explored by a party designated in books as the "Exploring Expedition of Red River," in which Capt. Sparks, Mr. Freeman, Lieut. Humphrey, and Dr. Curtis figured. Their designs were summarily frustrated by the appearance of a Spanish force 635 miles from the mouth of the river, who refused to permit any further progress, and the expedition was compelled to return.

In 1811 H. M. Brackenridge performed a journey up the Missouri in company with Manuel Lisa, under the following circumstances: After the expedition of Lewis and Clarke, a fur post was projected upon the Missouri, as the traders, and especially one man—Manuel Lisa—a determined and energetic spirit of the times, had been quite successful in adventures of this sort. This led to the organization of the Missouri Fur Co. Twelve men ascended the Missouri in 1808, in the spring, and left trading establishments in the Sioux country and among the Arikaras and Mandan Indians. Thence they proceeded to the three forks of the Missouri, viz., the Jefferson, Madison, and Gallatin. But the Blackfoot Indians, aroused to a sense of hostility by the death of one of their tribe in the previous expedition of Capt. Lewis, interfered with the settlement and harassed the trappers to such an extent that the enterprise at this point seemed impracticable. Mr. Henry, one of their number, crossed the Rocky Mountains and established himself on one of the branches of the Columbia, where he remained until 1811. Losses ensued, and as it was unknown where Mr. Henry and his party were, the expedition, of which Mr. Brackenridge was the chronicler, resulted. Twenty-five men composed the party, and as the Indians were in a state of irritation and resentment, the expedition was not undertaken without considerable risk. Just in front of them, bent upon the same errand, was a Mr. Hunt, in whose party were a Mr. Bradbury and Thomas Nuttall, the celebrated naturalist. These parties combined. Mr. Henry returned over the Rocky Mountains and joined Lisa at an Arikara village, and came back with him. Mr. Brackenridge's work is entitled "A Journal of a Voyage up the River Missouri in 1811," Baltimore, Coale & Maxwell, 1816.

The book is a brief and entertaining diary, fragmental and rudimentary, containing as an appendix an account of Mr. Sibley's trip across the country between the Missouri and Arkansas.

In April, 1819, under the directions of the Secretary of War, J. C. Calhoun, Major Long started from Pittsburg to explore the Missouri, the Mississippi above the mouth of the Missouri, the Red and Arkansas rivers, and the country between the Missouri and the Rocky Mountains.

The latitude and longitude of conspicuous points, the topography, character, situation, and habits of Indians were to be determined, and the zoological features. Dr. Baldwin was botanist, T. Say zoologist, Mr. Jessup geologist and mineralogist, Mr. Pearl assistant naturalist, and Mr. Seymour painter. Dr. Baldwin died during the early days of the expedition, and Mr. Edwin James, who compiled and published the notes, received the botanical collections for determination.

The expedition was crippled in its resources, and did not complete its extensive programme. The collections made were quite large, and at a time when systematic inquiry in natural history was comparatively recent they yielded great numbers of new species. These specimens were handed over to the Philosophical Society of Philadelphia, whose members furthered the enterprise with advice and influence.

This is known as Long's first expedition, and the narrative with atlas was published in 1823, in Philadelphia. It is a valuable and not common work. The expedition's equipment in specialists was more normal than any that had preceded it, and the natural history notes throughout are lucid and numerous.

The discussion upon the character of the several sections of country, nature of the rivers, and culture of the Indians is varied and able. The geology, in the light of modern classification, is useless. It was written at a period when the great groups were not outlined nor their subdivisions known, and when American students endeavored to decipher in the rocks of this country the stereotyped divisions of the Wernerian school, viz.: the primitive, transitional, and secondary rocks.

Later standards are so much more intelligible and real that these—certainly valuable then and approximative at times to facts—appear at this date very archaic. It is exceedingly difficult to parallelize this old terminology with modern formations and groups. The primitive designated the oldest granitic and archæan areas and some crystalline limestones; the term transitional was applied to the metamorphosed slates, schists, and limestones, and comprehended what is named in Long's report as the metalliferous limestone, clay slate, graywacke, graywacke slate, and curiously the old red sandstone or Devonian seems to be placed here. The secondary may be said to have been applied to the fossiliferous rocks.

The geology of the Rocky Mountains, which is assigned to the secondary formations, along the eastern base of the Rocky Mountains is described as, 1st, red sandstone, containing gypsum, and salt, and iron; 2d, argillaceous or gray sandstone, containing coal and iron; 3d, greenstone and graystone, the so-called floetz trap rocks.

The geology of the Ozark Mountains was made out as, 1st, granite; 2d, argillite; 3d, transition sandstone; 4th, flint; 5th, limestone; 6th, argillaceous sandstone; 7th, diluvial deposits.

In 1819 Thomas Nuttall started on a tour into the interior of the Arkansas Territory. His book is an interesting narrative of natural history, field notes upon geology, Indian habits, mounds, etc. The book, which contains his recollections, is entitled: "A Journal of Travels into the Arkansas Territory during the Year 1819, with Occasional Observations on the Manners of the Aborigines, illustrated with a map and other engravings," Philadelphia, 1821.

DAILY VARIATIONS OF THE STRENGTH OF THE WIND ON LAND AND AT SEA.

THE researches of Herr W. Koppen on this subject have been recently laid before the public in the "Naturforscher."

Though the daily periods of temperature and of barometric pressure, as well as a number of other meteorological elements, have been for many years the subject of close examination, it is only of late that the daily period of the strength of the wind has been taken into consideration. Yet this very feature shows itself more distinctly and generally than any other meteorological element, with the sole exception of the temperature, and perhaps of relative moisture. As will appear below, the daily period of the strength of the wind is perhaps even of greater significance than that of the variables just named. The most striking characteristic of this periodicity is the intensification of the wind in the hottest time of the day—a feature which, according to Hann, is recognized in all Continental stations, whatever may be their climate or the prevailing character of their winds.

This daily maximum of the strength occurs in Upsala, Cracow, Hamburg, and Dresden at 1 p.m.; at Vienna, Birmingham, Liverpool, Toronto, Calcutta, and Ascension at 1.30 p.m.; at Prague, Oxford, Batavia, and Melbourne, 2 p.m.; Petersburg, Halifax, Mauritius, 2.30; Bern, 3; and Rome, 3.30 p.m. At these places the entire daily variation in the strength of the wind takes place while the sun is above the horizon. During the night the wind is equally low, and even in the first hours after sunrise it varies little from the nocturnal value. The wind arises, especially on clear days, some hours after daybreak, and subsides again at night. In the intermediate time it increases toward noon; and in plains, in the interior of tropical and subtropical continents, it reaches daily almost the intensity of a storm. This is especially the case in the region of the trade winds and in the dry season.

In the open sea, as has been recently shown by Mr. Buchan from the observations made on board the Challenger, the case is quite different. In the middle of the ocean there is scarcely any appreciable daily variation in the strength of the wind. It retains during the night the same relatively high figure which appears by day. According to two concordant observations, however, the trade wind shows a slight periodicity, the maximum being at 8 a.m. and the minimum at 4 p.m.

The increase of the speed of the wind in the warmer hours of the day, observed as a universal fact on land, is confined, however, to strata of air which are for considerable distances in direct contact with the earth's surface. In the free, upper regions of the air, the wind is not stronger at noon than at morning and evening, but weaker. This fact was first demonstrated by Hellmann on Mount Washington and on the Righi. Koppen gives several other instances of a similar nature.

As far back as 1840 Espy gave a satisfactory explanation for the main features of the daily periodicity of the wind: "The beginning of the formation of ascending columns of air in the morning will be accompanied by an increase in the strength of the wind, and its strength will grow with the increase of these columns, both phenomena keeping step with the rising temperature. This acceleration of the wind is in part determined by the influx of air on the earth's surface from all sides toward the center of the rising columns, which thus produces inconstant breezes; in part also by the descent of air in the regions surrounding the ascending columns. Such descending air retains the velocity which it possessed in the upper regions, and which is well known to be greater than that of air in immediate contact with the earth's surface."

Without any knowledge of Espy's explanation, Koppen, as far back as 1879, while discussing Hann's observations, propounded the hypothesis that the daily periodicity of the wind depends on two conditions: 1st, the varying intensity of the perpendicular exchange of air in the lowest 1,000 to 4,000 meters of the atmosphere, with a motion which on the average increases from below upward, on account of diminishing friction; 2d, the preference of the warmer hours of the day, in consequence of the appearance of steep gradients by difference of pressure at small distances. This explanation is practically at one with that of Espy—a fact so much the more interesting as the latter *savant* had at his command in 1840 but a scanty array of facts for his inferences, while now a formidable series of arguments can be produced in favor of this hypothesis.

The latter of the two causes mentioned consists in the especial occurrence of thunderstorms, with their accompanying depressions, local whirlwinds, etc. The nature and the local movement of the gradients may be seen strikingly illustrated in Coppen's memoir on the thunderstorm of August 9, 1881. As these gradients may have very different directions, and may be propagated very differently, all the winds may undergo in the course of time such temporary accelerations, which, by their occurrence in the hottest part of the day, contribute essentially to the known form of the wind on land.

But this cause accounts for merely a subordinate portion of the phenomena of the daily period of the strength of the wind. This is shown by the fact that the mid-daily acceleration of the wind is often very distinctly characterized in cases where the foregoing explanation is manifestly inadmissible. This is especially the case in great aerial currents which retain an approximately constant direction. As examples we may take the trade wind in the dry season in the interior of Africa and South America, and the persistent east winds accompanied by dry clear weather in the temperate zone.

The efficacy of the other cause, which we must consequently acknowledge as the main cause of the entire phenomenon, is easily seen. The velocity of the movement of the air augments, generally speaking, from the earth's surface to a great altitude, on account of the decrease of friction. When, therefore, masses of air arrive from the heights at the surface of the earth they bring with them, generally speaking, a greater horizontal velocity than the masses of air under the same gradient which have been in prolonged contact with the earth's surface.

Since cold air, at the same external pressure, is denser—or, in other words, heavier—than warm air, there follows, when the magnitude of the decrease of temperature exceeds a certain value, an unstable equilibrium. A mass of air which has begun to sink becomes denser than its surroundings, and thus is impelled to sink lower, and, inversely, a mass of air which rises is inclined to further ascent. The vertical decrease of temperature which corresponds to this unstable equilibrium is 1° C. per 100 meters for dry air, and between ½° and 1° C. for moist air. If this value is reached everywhere, or partially over a large surface, there occurs a play of descending and ascending currents of air which in

damp weather makes itself manifest by cumuli piled up like mountains with blue interstices. The clouds represent masses of air which are ascending, in consequence of the decrease of pressure on being refrigerated. Hence a part of their moisture is separated out in the shape of the minutest drops, forming clouds. The clear, cloudless intervals are formed by descending masses of air which are experiencing the opposite process, of increasing temperature and heat, and are consequently removing further from their point of saturation.

The mean value of the decrease of temperature upward is greatest in the warmest hours of the day. In the night the difference of temperature between above and below becomes insignificant. In clear nights there is even, up to a certain altitude, a regular inversion of the difference, the temperature at the earth's surface being lower than it is above. This involves a very stable equilibrium of the air and a very trifling vertical circulation. In calm days, with bright sunshine, therefore especially in summer, the previously mentioned unstable equilibrium sets in a few hours after sunrise, and ceases a short time before sunset. The daily period of the velocity of the wind has the greatest correspondence with the formation of cumuli; but the connection of the two phenomena is far from complete, since the formation of cumuli demands a certain degree of atmospheric moisture, and depends also on perpendicular currents which do not necessarily extend down to the lowest stratum of the air.

The correctness of these views is demonstrated by the fact that a series of conclusions which necessarily follow are unmistakably confirmed by observation. These are accordingly here enumerated:

1. Wherever the daily variation of temperature and the retardation by friction are both very trifling, the mid-daily intensification of the wind—or, more strictly, the nightly lull of the wind—is wanting, even at the surface of the earth. This occurs on the open sea. The very slight friction at the surface of the water determines a very slight increase of the wind on ascending. Again, the perpendicular currents are substantially not connected with a daily period, as the daily fluctuation of temperature, even in the lowest stratum, does not exceed 0·7° C.

2. Where the intensified perpendicular circulation of the air in the warmest part of the day brings air from tranquil strata, there occurs an inversion of the period. The warmest hours of the day are then marked not by an increase, but by a decrease in the strength of the wind. This is the case on the summits of mountains which rise to a certain height over a varied landscape with a well marked daily fluctuation of temperature, but which do not themselves greatly influence the surrounding atmosphere.

3. The daily period of the wind displays characteristic relations to other phenomena, especially to vapor-tension. In all districts where the circumstances are favorable to a periodical powerful development of the perpendicular circulation at the hottest time of the day, and where accordingly the mid-daily intensification of the wind is distinct, the vapor-tension, as far as is known, has its minimum in the warm hours and its twofold maximum in the morning and evening. This decrease at the time of greatest heat can be explained only by the fact that air, poorer in moisture because warmer, arrives from the upper regions to the surface of the earth. This phenomenon occurs only at the bottom of the atmosphere in valleys or on plains. On the mountain tops the vapor-tension, like the period of the wind, is inverted, the maximum occuring when the warm moist masses of air rise up from low-lands.

4. On those sea-coasts in the region of the trades which have no regular sea-breeze, the trade-wind blowing over the land blows more strongly by day than by night, and shows the same daily period of velocity as is found in the interior of the continents. Of this a signal proof is given by the indications of the anemometer at St. Helena and Ascension.

5. The diminution and inversion of the daily periodicity of the wind on high mountains does not depend on the absolute height above the sea-level, but on the free exposure of the station on a summit of sufficient height above a varied region. Thus Koppen made observations on the Puy de Dome and on the Pic du Midi. On the former he observed a decrease and on the latter an increase of the wind at noon. The explanation of this apparent anomaly is that the station of the Puy de Dome is situate on an open, rounded summit; that on the Pic du Midi lies 500 meters below the summit.

6. Researches on the relation of the velocity of the wind to the gradient, which have been undertaken by Mr. C. Ley for England, and by Herr Sprung for the German coasts, give the accordant result that at 8 a.m. one and the same gradient is accompanied by a stronger wind in summer than in winter; stronger, also, with a northeasterly than with a southwesterly wind. But according to the researches of Hann and others, the decrease of temperature upward is on the average greatest in summer, and in time of northeasterly winds. As the magnitude of this decrease is generally parallel to the strength of the perpendicular exchange of air, it follows that for equal gradients there ensues a stronger wind when this exchange of air is brisk than when it is feeble, as the theory demands.

7. A particular importance attaches to the observation made independently by HH. Hjelström and Sprung, that cloudiness has a well marked influence on the daily period of the wind. During east winds with a bright sky the daily variation is more distinct than during westerly winds accompanied by cloudy weather. A clear sky which permits free radiation acts in two directions; by day it increases the vertical exchange of air by augmenting the vertical decrease of temperature, and consequently it intensifies the velocity of the wind in the lower strata of the air. At night, by refrigerating those strata it produces a firm equilibrium in the vertical direction, and thus withdraws the lower air from the influence of the upper, more rapidly moving, atmospheric strata. If the gradients are the same, there is therefore a stronger wind by day and a weaker by night in clear weather than under a cloudy sky.

8. Perhaps the most interesting feature of the daily periodicity of the wind is its relation to the daily variation in its direction. In a special memoir on this subject Herr Sprung has shown that an intensification of the wind while the gradients remain unchanged is, under ordinary circumstances, conceivable only if the angle of deviation is simultaneously augmented. In fact, the observations made at eighteen stations in the interior of the Eastern Continent show, in the forenoon, on the average, a decided deviation of the wind in accordance with Dove's law of deflection, while in the afternoon deviations in the opposite direction slightly predominate. The predominance of deviations of the wind along with the course of the sun—which is determined by the position of the north temperate zone with reference to the predominating tracks of barometric minima—is increased in the forenoon, but decreased in the afternoon, by a cause acting periodically. This cause is the descent into the lowest stratum of the atmosphere of masses of the upper air which are moving more rapidly and at a greater angle to the gradient. On account of the increased angle of deflection the track of the clouds deviates, as is well known, to the right hand of the wind. Observations on cloud-movements reveal, in the upper strata of the atmosphere, a daily period in the direction of the wind opposite to that which obtains below, quite analogous to the inversion in the period of its velocity.—*Journal of Science.*

JAPANESE FIREWORKS.

THE culture of the physical sciences, and particularly of chemistry, is making great headway in the extreme East. Mr. Billequin, formerly an assistant to Mr. Payen at the Conservatoire des Arts et Metiers, and at present professor in the Imperial College of Pekin, where he has been teaching in Chinese for the last eighteen years, has recently communicated to the French Academy of Sciences an elementary chemistry and a treatise upon analysis in Chinese text. The chemical industries are developing considerably in China, and a large manufactory, recently constructed, is already producing in that country large quantities of sulphuric acid.

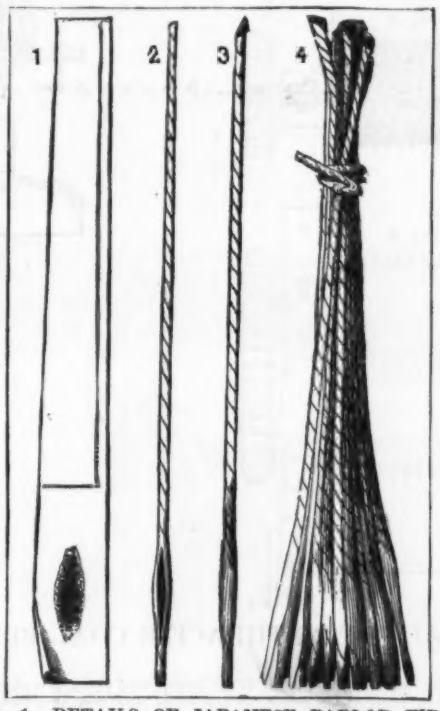


FIG. 1.—DETAILS OF JAPANESE PARLOR FIREWORKS. (Actual Size.)

This product, as well known, forms the base of the majority of the chemical industries; it serves to produce all the other acids, and, without it, we could not manufacture stearine candles and many other useful products.

Though the Chinese and Japanese have yet much to do as regards industrial chemistry on a large scale, they have always been acquainted with a multitude of ingenious processes of manufacture, and with general ideas of science. We remember that, about twenty years ago, while we were manipulating in one of the laboratories of the Conservatoire, we were present at a visit that the Japanese ambassadors paid our great national establishment.

FIG. 2.—PARLOR FIREWORKS BURNING.

In Mr. Peligot's laboratory a few interesting experiments had been prepared, and our friend, Mr. L'Hote, who has since become one one of our most distinguished chemical experts, burned some potassium upon the surface of water. One of the Japanese approached and made a sign that he was acquainted with that experiment, and unhesitatingly pronounced the word *kalium*, the Latin designation of the alkaline metal in question.

We remember that one of the assistants turned to us and said: "I believe that many of the ambassadors of our regions could not perhaps say as much!"

How many of the processes of the extreme East still puzzle our chemists! The manufacture of lac, India ink, and vermilion, the metallurgy and manufacture of tam-tams, the manufacture of certain papers and of several kinds of varnish are still carried on in the Celestial Empire by means of processes that we have up to the present sought for in vain.

The Chinese and Japanese have for centuries excelled in the art of pyrotechny, and our readers are assuredly acquainted with those small parlor fireworks which produce so curious an effect and which have long put the perspicacity of our chemists to the proof. It is upon the subject of these that we shall on the present occasion publish some details that are very little known.

These parlor fireworks, which are found in most depositories of Japanese articles, or with dealers in toys, consist of small paper rolls that are lighted while held in a vertical position with the larger end pointing toward the floor (Fig. 1). When a light is applied to the extremity, a ball of fire is observed to gradually form, and from it shoot a series of pretty sparks and tufts of light, which form a brilliant crown, and which are comparable to those produced by pyrophoric fire, though much more regularly ramified (Fig. 2). This ball gradually diminishes in size, and the rays become concentrated until the object stops burning.

A master pyrotechnist, Mr. A. Denisse, who has published a complete treatise upon fireworks—a work remarkable for the perspicuity of its descriptions and the number of documents that it contains—has communicated some information to us upon this subject which we shall reproduce.

The above-mentioned fireworks, attributed to the Japanese, have for a long time attracted the attention of observers, but the preparation thereof has always been kept a secret.

"We have," says Mr. Denisse, "been unable to find a description of them in any treatise upon pyrotechny. Persons in the trade have told us that they have endeavored to reproduce the mysterious sparks by means of pulverized metals, but, not succeeding, have come to the conclusion that these singular fireworks must contain a peculiar, undiscoverable substance."

A distinguished chemist, Mr. Tessier, has analyzed these Japanese objects with the greatest care, and has found that in 50 parts by weight they contain 27 of saltpeter, 14·35 of sulphur, and 8·65 of charcoal.

Certain chemists have said that there must be other products present in order to produce the mysterious sparks. But it appears that there is nothing in this, and that those thousands of sparks that shoot out from an incandescent droplet are due to no metallic substance, but to the nature of the paper used, and that too through an as yet unknown cause.

"The discovery of this combination," says Mr. Denisse, "can be attributed to accident only, since it was impossible

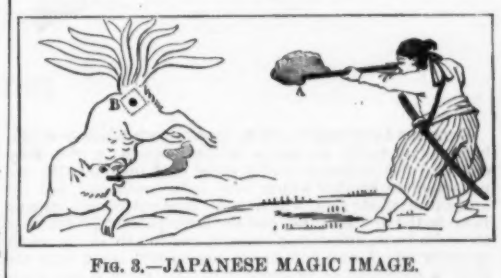


FIG. 3.—JAPANESE MAGIC IMAGE.

to foresee so surprising a result from the materials employed, and the discovery must have been made in Japan rather than elsewhere, for two reasons, to wit: (1) from the use in that country of slow matches formed of a train of powder inclosed in small strips of paper; and (2) because nearly all Chinese papers concur in the production of the mysterious ball. This is not the case everywhere, in France, for instance, where it is difficult to come across paper that possesses the requisite qualities.

"With certain papers there is a copious production of sparks, while with others the result is absolutely negative. The ashes of the paper absorbed by the ball evidently play a part, and it is therefore indispensable to make a proper choice of paper.

"We have found three kinds of silk paper that are adapted for the purpose: (1) white, unsized, English tissue paper (such as is used for making flowers), which produces large sparks, but few in number; (2) a gray, silky, French paper, soft and unsized, analogous to that used by pastry cooks sometimes for wrapping cakes in; and (3) the paper manufactured in China and Japan and sold at Paris."

The following is the formula that has given Mr. Denisse good results in the manufacture of these Japanese fireworks: Dust of blasting powder 28 parts, saltpeter 54, sulphur 39, light charcoal 8, oak charcoal 8, and lamp black 5, forming 142 parts by weight. The whole (with the exception of the charcoals, which are simply sifted) is triturated moderately and finally mixed.

On another hand, Mr. Tessier has obtained excellent results with the following formula, to wit: Saltpeter 25 parts, unwashed flowers of sulphur 16, willow or poplar charcoal 6, and stearic acid (candle grease) 2, forming a total of 49 parts by weight. After passing the substances through a silk sieve, they are to be intimately mixed by triturating them together for one or two minutes.

The fireworks are formed as follows: At one of the extremities of a strip of paper 0·10 m. in length by about 0·012 m. in width are placed two or three centigrammes of the composition. The paper is then twisted spirally, an operation that may be facilitated by a knitting needle placed upon the composition. The paper is twisted so tightly that it cannot unwind, particularly above the powder, and then the needle is removed. The fireworks thus made give, upon combustion, the results that we have described, and the explanation of which is yet to be found.

As a conclusion to this article we offer our readers a curious pyrotechnic secret of the far East that Mr. Denisse has likewise taught us, and that concerns the preparation of Japanese magic images such as shown in Fig. 3. Upon touching the point, A, at the extremity of the hunter's gun, with a red hot pin, a streak of light is at once seen to flash from A to B, and cause a slight detonation. The hunter has killed the tiger

This curious result is obtained as follows: When the drawing has been made upon a sheet of common paper, a small pencil is dipped into a concentrated solution of saltpeter, and a line is drawn therewith from A to B. This line of saltpeter when dry is invisible.

At the point B there is fixed behind the drawing, by means

of a small square of paper and some starch paste, a small quantity (in bulk about the size of an ant's head) of fulminate of mercury. The experiment is now ready to be tried.

Is this not interesting? And are we not right in saying that the Japanese are often our masters in certain ingenious and attractive chemical processes?—*G. Tissandier, in La Nature.*

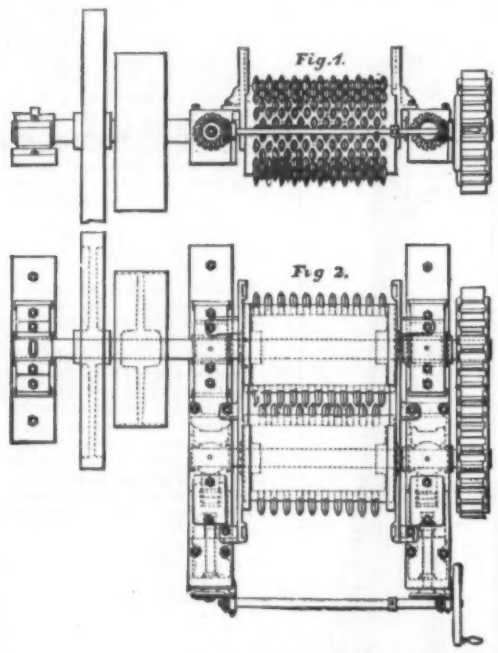
AN AMERICAN COAL BREAKER.

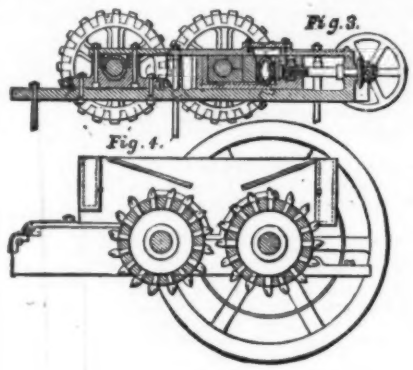
IT is obvious, that in separating the coal, as many chutes are required as there are classes of delivery. At most collieries water is only used in the course of preparation during the early stage, and at the mud screen, as already mentioned, but where the anthracite is very hard, the practice prevails of washing it continuously at every stage, water being supplied freely for this purpose to all the screens.

and in which trees of considerable size have even found a footing. Up to the present time all this has been practically a waste product, although of late years attention has been seriously turned to the utilization of this pure but hitherto unmanageable coal for purposes of fuel.

Having thus given some general idea of the operations required for preparing anthracite coal for the market, we may consider in more detail one or two of the best examples of breakers. The coal breaker which we illustrate is an example taken from the collieries of Mr. Eckley B. Coxe, in Lucerne County, Pennsylvania, and is probably one of the most perfect that could be selected. It is situated at the outlet of a slope of which the incline of the breaker, reaching to the top of the building, forms a continuation. The wagons on arriving at the foot of this incline are attached by a chain passing up it over rollers, and around a sheave at the top, and so down to the drum of a hoisting engine. At

and here the first work of division takes place, part passing through the bars, and the remainder traveling onward over them. What falls through is received into the so-called mud-screen pocket, the lower part of which is closed by a gate; this gate gives access to the hopper leading into the mud screen. We may follow this portion of the coal on its way through the breaker. Water is plentifully supplied to this screen, and the coal is throughly washed before it falls through to be subdivided, and in the course of this process it passes over at least six chutes and through three screens. The largest size, which passes over all the meshes of the screen, is received upon a chute, D^1, in sliding down which the slate is removed by hand. The coal passing through the 3 in. meshes of the screen falls upon the apex of a double inclined plane, shown in the drawings, and it is directed in about equal proportions upon the west chute, P, and the east chute, R, where it falls into screens Nos. 1 and 2, and





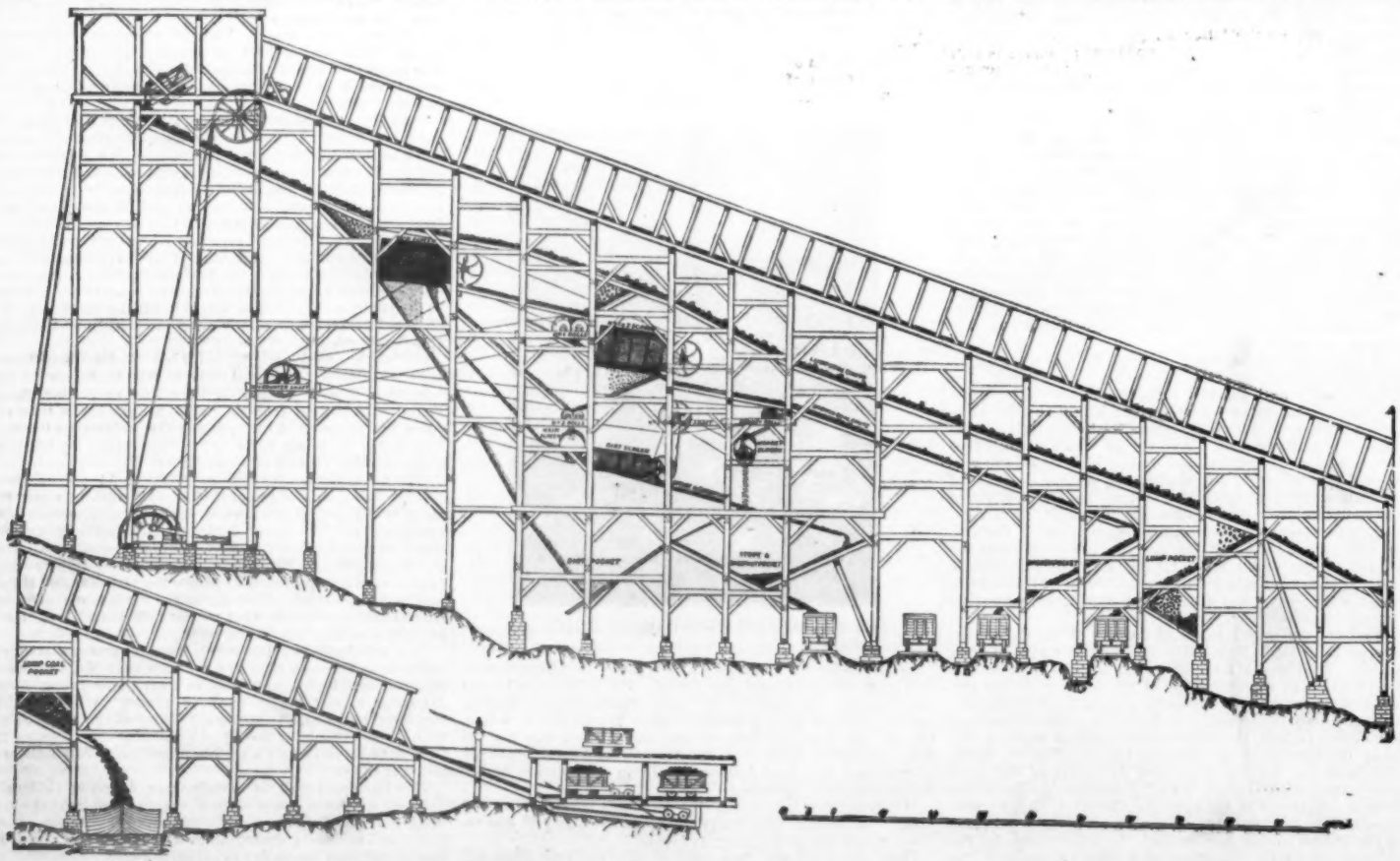
DETAILS OF ANTHRACITE COAL BREAKER.

From the foregoing it will be readily understood how elaborate and costly a process is the preparation of anthracite coal for shipment, and it is not only the operating expenses in the breaker which have to be considered, but the amount of waste also, which is an unavoidable accompaniment to the process. Beyond the large percentage taken to the culm bank, amounting to about one-fourth of the whole quantity raised, and containing necessarily along with the slate a considerable proportion of coal, there is the waste product arising from the preparation, and this ranges very high even under favorable conditions of material and treatment. Pieces too small to find a market and the dust produced by the attrition of the vast masses of coal flying constantly through the breakers, at a high rate of speed, have in the course of years formed masses of incredible magnitude, which have transformed the very aspect of the country round the breakers into hills often grass covered,

the top of the incline is the dump, and above it a slope of somewhat steeper pitch, nearly to the top of which the wagons are hauled. The pin securing the end door is then removed, and the coal is discharged upon the dump. The empty wagon then runs down the track by which it came, and on arriving near the bottom it strikes a spring latch, which switches the wagon off on to another line of rails, by which it returns to the mine. The incline is provided with a double track, on which the wagons are constantly passing to and fro, the time being so arranged that they shall not cross each other at the switching place. The coal deposited in the dump is just as it leaves the mine, containing, besides slate, parting stone, and other impurities, a considerable quantity of dust. This all slides together down the first incline, which can be closed at its upper end by a gate, worked from a lever, as shown in the longitudinal section. Below this gate are the first set of bars, placed 3½ in. apart,

is further washed and sorted by passing through the meshes of the screen. Screen No. 1 also receives the coal passing through the 2 in. meshes of the mud screen, while that which escapes through the ¾ in. meshes is taken by chute F to the pea-coal screen, where water is added, and the coal is divided into two sizes, the pea-coal passing through the ⅝ in. meshes, and the buckwheat through those of ⅜ in. The dust, dirt, and water are carried off through the screen. The pea-coal screen also receives the pieces passing through the ¾ in. openings of screen No. 2, which in its turn is largely fed from the coal falling between the bars, L and G.

Returning to the larger coal, falling from the dump over the bars, A, 3½ in. apart, we find it descend to a second set of bars, B, with 5½ in. spaces between them; that part falling between these bars is received upon the apex of a double slope, similar to that already referred to, and where a further



ANTHRACITE COAL BREAKER· DRIFTON LUCERNE COUNTY PENNSYLVANIA.

division takes place. One part falls in about equal proportions over these slopes into the chutes, B^1 and C^1, where as it falls it is hand-picked; but each of these chutes contains two sets of bars, F and L, with spaces 2½ in. wide between them. A part of this coal passes over both sets of bars, part falls between the north set of bars, L, and goes away to screen No. 2, and part falls between the south set of bars, F, and is taken off to the breaking rolls. The two-page plate we publish in our present issue shows the breaker to a larger scale, and on it the prepared coal can be clearly traced in its various stages of progress from the time it is being hoisted out of the mine to its ultimate delivery into wagons beneath the discharge hoppers. The various classes of coal are indicated, and their names appended, as well as the position of the dirt, slate, and other pockets. That part of the coal which falls between the bars, D, next passes over bars, G, placed 2 in. apart, and here a further division takes place, a portion going between and being led off to the screen No. 2, while the remainder goes to the hand-picking chute, E^1, and is thence taken to the rolls. There remains the still larger portion of the coal which passed overs the bars, B, placed 5½ in. apart; this falls upon the platform shown, where men separate the slate from the coal, and when necessary break the latter in order to clear it. From the platform it descends over the bars, C, the width between which can be adjusted from 4 in. to 8½ in.

The rolls used in different parts of a breaker, to reduce the coal to smaller sizes, are quite similar in construction, varying principally in dimensions rather than in principle of operation. Figs. 1 to 4 opposite are representations of rolls marked B and C in the previous tabulated statement and engravings. The rolls consist of cast-iron cylinders with holes bored in them, into which claws or spear-shaped steel teeth are driven, and these become quite tight with use. In case of the breakage of a tooth, its shank is driven through to the interior of the roll, removed from one of the open ends of the latter, and a new one inserted in the hole. The action of the teeth is to cut rather than crush or grind the coal. On the left hand is the driving pulley, and on the right is a handwheel, which, in connection with the intermediate rods and gearing, is used in increasing or diminishing the distance between the rolls, as may be desired; the gear wheels have very long cogs, to enable this to be done, and are shrouded to insure the requisite strength. Two cast-iron safety pieces are introduced, each of which will break under a pressure of about 2 tons. The strength of the working parts are proportioned in such manner that the safety-pieces oppose a less resistance than any of them, so that these will break and relieve the other parts of undue pressure, should large pieces of slate, other hard impurities in the coal, or, as sometimes happens, the tools of the workmen, become wedged between the rolls. One of the axles is provided with ball-and-socket bearings, as shown, so that when the axle becomes slewed, as is the case when one, not both, of the safety-pieces are broken, no injury will result to the other parts. A traveling chute is arranged to deliver its contents to be broken, between each pair of rolls, and whatever comes from the chute is prevented from taking any other course than directly down between them, by means of cast-iron or wooden sides. What comes from the rolls is caught underneath in another traveling chute. Rolls of the size represented in the engravings are run when in use at a speed of about 90 revolutions per minute, and the larger rolls, those marked A upon the general view, which are used to break coal into the steamboat size, are run about 120 revolutions a minute.—*Engineering.*

IMPROVED TORPEDO APPARATUS.

CANET'S gun for launching fish torpedoes has an improved arrangement allowing the use of ordinary gun-powder or similar explosive for discharging the torpedo, instead of compressed air or steam. The effort which the gunner has to make while firing is considerably reduced by using a spring, which is tightened beforehand so that, having laid the tube, he has only a slight effort to make in order to pull a trigger for firing, so that better aim is kept. The special arrangement of the carriage allows greater facility for training the tube without the aid of racers, as it adjusts itself to the slope of the deck.

The breech of the tube is closed by an improved mechanism which does not allow the charge to be fired unless the breech is properly shut. This arrangement prevents any accident which would happen should the breech be simply pushed home.

The charge of explosive to launch the torpedo is placed in a cup or chamber provided in the breech piece, and it is ignited by a fuse exploded by the mechanism illustrated above.

Fig. 1 is a longitudinal section of the breech end of tube and back part of carriage, and also a side view of fore-part of tube and longitudinal section of the front part of carriage; Fig. 2 is a back elevation of breech end of tube and carriage; Fig. 3 is a plan of fore-part of carriage; Fig. 4 is a plan of back part of carriage; Fig. 5 is a side elevation of discharging mechanism; Fig. 6 shows another combination of discharging mechanism; Fig. 7 is a cross section of tube on line, $x\,y$; Fig. 8 a cross section of tube, showing the starting catch, H. Fig. 9 is a section through M N of powder chamber.

The discharging mechanism consists of a system of levers and a spiral spring, P, that is tightened by acting on the crank lever, O^1, by means of a handspike that fits one of the extremities. This lever, O^1, is kept cocked by the catch lever, Q. Safety pin, q, prevents any sudden release of the mechanism. On the same axis on which is keyed the crank lever, O^1, are fixed two other levers; one the lever, O^1, that releases the torpedo inside the tube, and the other the lever, O, that works the firing mechanism. The general appearance of the apparatus is shown by the perspective view.

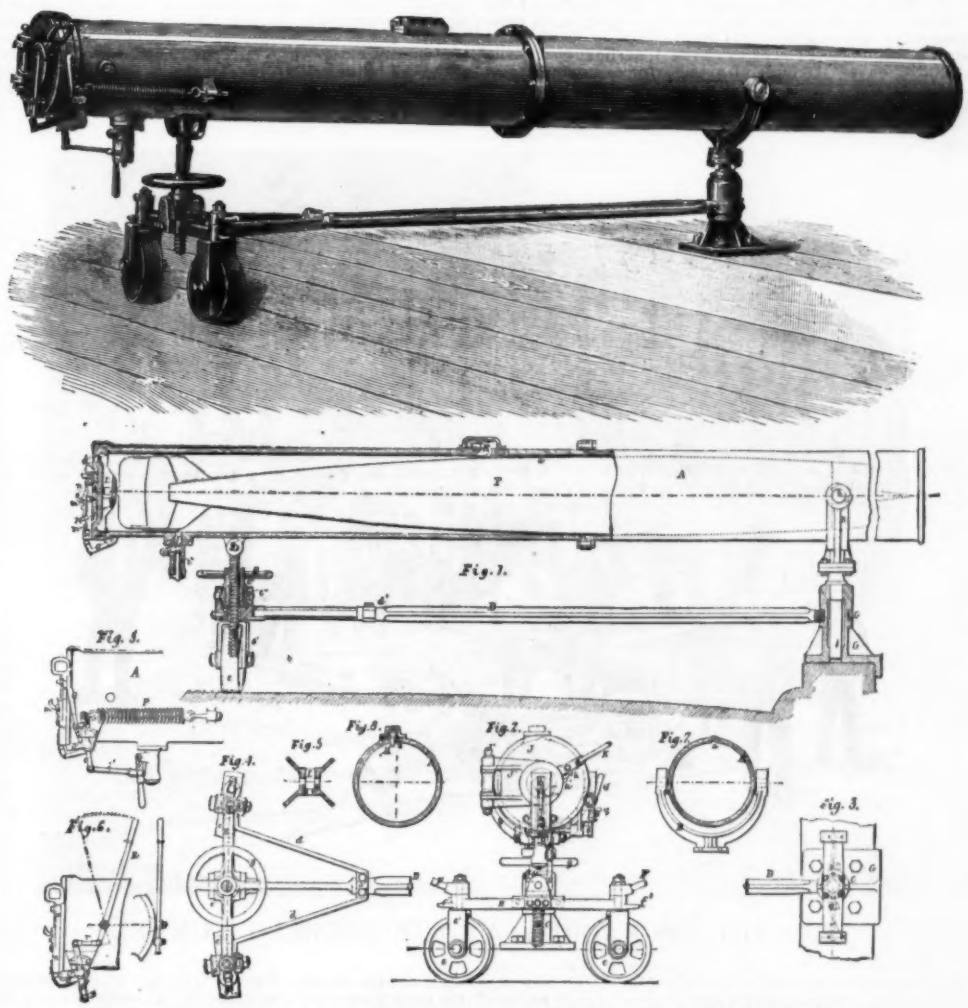
The actual working of the whole arrangement for launching the fish torpedo is as follows:

We will suppose that a fish torpedo has just been discharged. The gunner, by means of a handspike fixed at the end of a crank lever, O^2, Fig. 5, tightens the spring, P, which is kept cocked by the catch lever, Q; he also puts in the safety pin, q, and then, to open the breech, he catches hold of the small hand lever, K, and gives one-sixth of a turn to the screw that closes the breech. The threads of this screw are partly cut away like those in the screw breech of guns, and the threads themselves are conical; then, in pulling the lever, K, toward him, the whole of the breech swings round the hinge, J^2, Fig. 2, and the tube is ready to receive a torpedo, which is introduced carefully into the tube, while the stop bolt, I, Figs. 1 and 5, inside the tube is lowered by means of the hand lever, i, until the torpedo is well home; when the man lets go the hand lever, i, the spring, i^2, is liberated, and the bolt, I, maintains the torpedo inside the tube.

The charge of gunpowder or any other explosive is then put into the powder chamber or cup, L; this chamber is pierced with holes radiating from its center, so that the gases rush against the inner surface of the tube, thus preventing any damage to the torpedo.

The breech is closed by swinging it round the hinge, J^2, till it is home, then by the handle, K, the screw of the breech is turned one-sixth round, care being taken to release the catch, K^1, in pressing with the thumb on the spring.

To prevent the escape of gases, the breech presses a ring of leather or abestos let into the internal face of the breech. In order to introduce a new fuse, the hammer, m, Figs 1, 2, and 5, must be pulled out and pushed down the inclined planes, and the fuse is then put in. The gun so loaded is ready for a new discharge. If the breech is not well closed, the end of the lever, O, will not enter into the slot of the hammer, and the fuse could not be exploded. This mechanism is, therefore, also a safety arrangement. To fire, the gunner pulls out the safety pin, q, and, by exerting a slight effort toward him with the handle of the catch lever, Q, he releases the spiral spring, P. The rotary motion imparted to the axis that carries the three crank levers before described removes first the stop bolt, I, inside the tube and immediately afterward explodes the fuse. The exploding of the fuse is produced as follows: On the slide piece, m', is fixed the hammer, m, which carries on each side a stud. The slide piece is pushed upward by the lever, o. This tightens the spring, m^2, and when studs are at the summit of the inclined planes, the hammer is released and strikes the fuse, which explodes. Inside the tube, and fixed at a proper distance, is the usual spring catch, H, Fig. 1, which acts on the starting valve of the engines inside the torpedo itself as it is shot from the tube. The above arrangement has been described for a percussion fuse. In some cases an electric fuse is used,



IMPROVED APPARATUS FOR LAUNCHING TORPEDOES.

and it is by the sliding up of the piece, m, that the circuit is closed and the charge exploded. The construction of the carriage is as follows:

The front part of the carriage consists of a crosshead, B, bearing the trunnions, b, Fig. 1; this crosshead turns round on a pivot resting on a strong bracket, C, so that it can be fixed for firing either at the fore or aft part of the ship or broadside.

The hind part or breech end of the carriage consists of a V-shaped frame, E d d, which rests on two rollers, e, that may turn when required in any vertical position. The front beam, E, of this frame has a hole in its center to let the elevating screw, G, pass through it.

This screw, G, is fastened to a lug under the tube, and it is worked up and down by the nut, e', cast with the hand wheel, g. The nut itself turns in two half bearings, e''', provided with horizontal trunnions working in the front beam, E.

The front and rear parts of the carriage are kept together by means of the connecting rod, D. This rod at its front end turns horizontally round the bracket, C, and is attached to it by means of the collar, c. At its rear end the rod is attached to the V-shaped frame by means of the collar, d^2, and the extreme end of the connecting rod turns in a socket provided in the beam, E.

This mode of connecting the rod to the rear part of the carriage allows the V frame and rollers to follow the slop of the deck without interfering with the laying of the tube.

The cartridges used in firing the gun are of course specially prepared. They require in their manufacture a great deal of attention, and the proportions of each quality of powder used have been determined after repeated trials. The cartridge burns slowly at first before the torpedo moves, and then at an accelerating rate, so that the pressure of the gas does not injure the torpedo itself.—*Engineering.*

STEEL BEAMS AND STRUTS.

AT a recent meeting of the American Society of Civil Engineers, in this city, a paper by James Christie on "The Strength and Elasticity of Structural Steel and its Efficiency in the form of Beams and Struts" was read by the author. He said that the various grades of steel possess such a range of physical properties that it is impossible to consider the metal as one might treat of iron.

It is customary to denominate the grades of steel by the percentage of carbon they contain. The higher the carbon the higher the tenacity of the steel and the lower its ductility. Steel whose carbon is below fifteen hundredths per cent. is conventionally known as *mild* or *soft* steel. The steels subjected to the tests described in this paper were of two distinct grades—*mild* and hard; both being products of the Bessemer converter; the hard steel having thirty-six hundredths per cent. of carbon, and the mild steel twelve hundredths per cent. The tensile tests were made on strips about 25 inches long, to which were clamped plates exactly 12 inches apart. The compression tests were made on specimens 12 inches long, inserted in a tube, and the space between the specimens and the tube filled with fine sand. The tests on transverse resistance were made on bars of 3 or 4 inches diameter, and on solid flanged beams from 3 to 12 inches deep, all being supported at the ends and loaded in the middle.

Extended tables were then presented of these various tests, and it was stated that the results showed that the elasticity of steel and iron is practically uniform; the steel may stretch less than the iron in tension, but the steel shortens most under compression. Transversely, if there is any practical difference, the advantage in stiffness probably belongs to steel, but the elasticity of both metals is so close and uncertain that further experiments may modify the average results here found. The specimens show that the elastic limits for tensile and compressive stress for the different grades of steel are practically equal per unit of section, and the transverse resistance is approximately proportionate to the longitudinal resistance, and that the strength of the material indicated in tensile stress will serve as a comparative measure of the absolute strength of iron, or of either grade of steel; but as the transverse elasticity is practically alike, beams of iron, or of either grade of steel of the same length and section, will deflect alike under equal loads below the elastic limit of iron.

Tables were presented of experiments on flat ended struts of both mild and hard steel. It was stated that the experiments on direct tension and compression prove that the elastic limits of steel of any particular grade are practically equal per unit of section for either direction of stress. A similar equality is known to obtain with iron. Therefore, for the short struts in which failure results from the effects of direct compression, the tensile resistance of the material will serve as a comparative measure of strut resistance. As struts increase in length, the lateral stiffness becomes a factor of increasing importance.

The transverse elasticity of steel and iron does not vary much. The tendency will be for struts of steel and iron to approach equality of resistance as the lengths are increased. Mild steel will fall to equality with iron when the ratio of length to least radius of gyration is about 200 to 1. Hard steel would fall to practical equality at the point beyond the bounds of practice.

This paper, and the paper previously presented by Mr. Christie giving experiments on the strength of wrought iron struts, were then discussed.

Mr. A. P. Boller expressed the opinion that the variations in the compressive resistance of iron shown by these very careful experiments were so great that it was impracticable from them or from any other experiments so far as had yet been made to prepare a formula which would ever give satisfactory results, and that dependence must be placed upon experimental charts which will express extreme values for all sections progressively determined.

Mr. Onward Bates considered that the experiments developed the great importance of placing the center line of pressure coincident with the center of the struts. If this could be done perfectly, a round ended strut would be as good as a flat ended one. In actual practice in the construction of bridges the methods of securing the ends of such struts are so various, that it is impracticable to make from such experiments a table of safe loads. The only safe practice is that of low unit strain corresponding to the lowest results of recorded tests.

Prof. E. A. Fuertes considered that the areas of cross sections should be obtained by direct measurement instead of deriving them from the weight and length of the bars, particularly when the specific gravity of the material is not determined. The reason why an accurately centered straight bar behaved as a flat ended strut when hinged is due to the friction developed by pressure on the bearing of the hinge, and the early failure of flat ended struts was probably due to the want of parallelism between the planes at the extremities, or the one or both of these planes being warped surfaces. Since a bar very long in proportion to its radius of gyration fails with a comparatively light load without permanent injury, it would seem proper that such load would be given a name other than ultimate load, the latter being restricted to its bearing on the elastic limit.

Mr. Theodore Cooper considered the experiments of Mr. Christie most valuable, particularly in carrying out a complete series with different end connections upon the same class of materials. The paper shows that slight changes in the direction of the lines of applied forces produce great changes in the results. By interchanging different sizes of ball and socket joints it shows the influence of the size upon compressive resistance of the struts. It gives a more complete knowledge of the action of struts of high ratios of length to transverse dimensions than before existed. The method of using the least radius of gyration instead of the last dimension gives a fair comparison between the various forms. Attention was called to the relation of the ball and sockets to the transverse dimensions of the struts, and diagrams were presented by Mr. Cooper showing the influence of the size of pins relative to the width of the struts. From the great effect of non-centering the line of applied force upon columns and of initial though minute bends in the materials and the increased influence of possible side blows, it is very important not only to keep the working strains within proper limits, but also to specify a limit to the number of diameters to be used in all columns. In recent specifications this limit has been about at 45 diameters, corresponding approximately to about 120 radii of gyration for the usual forms of bridge columns. With this proviso a practical formula may be reduced to very simple forms.

Mr. E. B. Dorsey presented some comparative tests of iron and steel.

The subject was further discussed by Messrs Bouscaren, Charles E. Emery, Pegram, P. Roberts, Jr., Towne, and Christie.

BRANDT ROCK DRILL AT THE ARLBERG TUNNEL.

THE ARLBERG TUNNEL.

IN the construction of the Arlberg Tunnel the first problem to be solved was that relating to the system of boring to be adopted. At the time the St. Gothard Tunnel was constructed no such question was raised, for the reason that at that epoch there was no other system in vogue than the percussion rock drill actuated by compressed air. The Brandt machine, which had already been employed in the piercing of the St Gothard (at the northern approach), was selected for the Arlberg works.

This machine operates through a hydraulic pressure of from 100 to 120 atmospheres, and pierces the hardest rocks after the manner of diamond rock drills, but with the use of steel tools. The drilling tool, which is annular in form, is given a rotary motion while being held firmly against the rock. The pressure of the tool against the latter results from the action of water compressed in a cylinder forming a continuation of the tool carrier. In the interior of this cylinder there is a plunger which abuts against the column that serves as a support to the apparatus. A rotary motion is given the tool by a cog-wheel keyed to the cylinder and actuated by a transverse endless screw set in motion by two small hydromotors placed on either side. The number of revolutions of the drill varies from five to twelve per minute, according to the nature of the rock. In the hardest rocks the drilling is effected at the rate of five revolutions per minute, and allows of an advance of four millimeters per revolution being made. The number of cutters put out of service at the Arlberg works was from three to four per meter. But as soon as a softer layer was reached the results were incomparably better, and an advance of twelve millimeters per revolution was made, the number of revolutions being from seven to eight per minute and the same tool being capable of serving for two or three meters.

Considering the unfavorable conditions under which this machine was constantly placed, it is impossible to judge of it definitely as compared with its competitor, the Ferroux machine. It must also be remarked that six of the latter machines were working simultaneously, while only three of the Brandt were operating, except later on, when this number was increased. The annexed engraving represents one of the Brandt machines.

The second question that engaged the attention of the engineers of the work was that of ventilation. At the St. Gothard, in order to improve an atmosphere vitiated by the products of the combustion of dynamite and by the respiration of the workmen, a portion of the compressed air designed for actuating the machines was led in by means of pipes connected with the main conduit. What then happened? It was this: the initial pressure of from six to seven atmospheres ran down to three, and even two, atmospheres at the end of the gallery, and for that reason was not sufficient. So at the Arlberg two distinct conduits were laid down—one of them of low pressure for ventilation, and the other of high pressure for the motors. The conditions of the grant prescribed a minimum of 150 cubic meters at each heading, a quantity that was to be increased in case of need. This quantity was increased at certain periods to 200 cubic meters.

An attempt was made to extract the vitiated air at the St. Gothard by means of a boiler plate conduit 1·2 m. in diameter suspended from the vault; but it was not carried farther than 100 meters from the mouth, and this rendered its effects null, since the works extended over several kilometers.

At the Arlberg a natural ventilation of the most favorable character was obtained through the working shafts, the smoke entering and making its exit therefrom.

We have no space to go into details regarding the motors situated on the two sides of the mountain, for their mode of installation merits a study by itself. They gave splendid results, since they allowed an advance of nearly nine meters to be made every fourteen hours.—*Science and Nature.*

THE RIACHUELO.*

THE RIACHUELO, BRAZILIAN ARMOR-CLAD TURRET SHIP; ITS CONSTRUCTION AND PERFORMANCES.

By Mr. J. D'A. SAMUDA, M.I.N.A., Vice-President.

THE great development that has lately taken place in the armor-clad navies of all nations, and the public interest attaching to every improvement in the speed, efficiency, and formidable character of vessels of this class, induce me to give an account of the general construction and performance of one of the latest type of ironclads, which I have just completed for the Brazilian Government.

The Riachuelo—for this is the name of the vessel referred to—is a steel armor-clad twin-screw turret ship, of 6,000 tons displacement and 6,000 horse power, and possesses in in speed, in coal endurance, or capability of steaming without recoaling, advantages that have not, I believe, previously been attained; while there are many points of interest in the arrangement and fire of her guns, her maneuvering powers, and general fittings, which I trust will be found of sufficient interest to justify a special reference to them.

* Paper read at the twenty-fifth session of the Institution of Naval Architects.

GENERAL STATEMENT OF DIMENSIONS, ARMAMENT, ENGINES, ETC., AND STATEMENT OF WEIGHTS.

Dimensions.

Length between the perpendiculars	305 ft.
Breadth of beam, extreme, on water line	52 "
Depth from garboard strake to underside of main deck	21 ft. 9 in.
Draught of water at load line, with 400 tons of coal in bunkers	19 " 6 "
Height of port above low water line	12 " 9 "
Displacement at load line	5,700 tons.
" per inch	31 "

Engines.

Indicated horse power	6,000
Estimated speed per hour in knots, with 872 tons dead weight on board	15 knots.
Complement of men and officers	250

Armament.

Four 9 in. 20-ton long breech-loading guns in two revolving turrets, and six 5½ in. ditto on upper deck, and fifteen machine guns.	
Height of armor above low-water level on breastwork	12 ft. 6 in.
Height of armor on belt	3 "
Depth below low-water line	4 "
Thickness of armor on belt	11, 10, & 7 in
" " breastwork	10 in.
" " turrets	10 "
Deck plating, main and lower decks	2 "
" deck over breastwork	3 "
Thickness of backing amidships	10 "

Statement of Weights.

Hull of vessel		1,760 tons.
Armor plates and fastening		1,120 "
Teak backing		130 "
Deck plating on main deck and over breastwork		350 "
Masts, spars, rigging, blocks, and sails		65 "
Anchors and cables		75 "
Boats, galleys, condensers, etc		35 "
Wool and metal sheathing		160 "
		3,695 "
Engines, boilers, and spare gear		1,070 "
Armament, guns, ammunition, small arms, turret engines, hydraulic apparatus, and other gear supplied by Sir W. G. Armstrong & Co.		
Officers, men, and effects		
Water for four weeks	472	
Provisions, spirits, etc., for twelve weeks		
Officers' stores, slops, wood, sand, and bolystone		
Warant officers' and engineers' stores		
Coal	400	
		872 "
(Exclusive of 400 tons of spare coal in reserve bunkers, 800 tons in all)		5,637

Displacement of vessel at load line 19 ft. 6 in. draught = 5,700 tons.
Displacement with reserve coal on board, 800 tons in all 20 " 6 " " = 6,100 "

The hull is built entirely of Martin-Siemens steel. The armor is compound or steel faced, consisting of an armor belt 250 feet in length, 11 inches thick amidships, where it protects engines, boilers, and magazines, then reduced to 10 inches thick, while the underwater portion (for 4 feet in depth) is partly 10 inches and partly 7 inches thick; and beyond the 250 feet of side armor at both ends, inclined armor is placed internally, 3 inches thick, at an angle of 15°, and reaching from the top of the side armor to the stem (and stern respectively), so arranged that the 3 inches inclined armor measures and equals 10 inches of vertical armor if struck in a horizontal position.

A horizontal deck of 2-inch steel armor running through the ship joins the inclined armor at each end, and on this is worked two oval breastworks, built up of plates and angles, and covered with armor plates 10 inches thick and teak backing; which breastworks encircle and protect two revolving turrets similarly built up and covered with 10-inch armor, in each of which turrets two 20-ton long steel breechloading guns are placed. The position of the breastworks being in echelon, and so carried out as to enable the guns in each turret to command an unbroken fire for 180° on its own side of the vessel, and 50° on the opposite side, so that the whole four guns can be brought to bear ahead or astern, while an all-round fire can be always maintained with two guns, and all four of them can be used for broadside firing on either side of the ship.

The penetration of these guns was found to be equal to piercing 18 inches of iron armor, with a considerable amount of energy to spare. The guns are loaded by hydraulic machinery, while the same description of machinery is made use of for revolving the turrets. The rest of the armament consists of six 70-pounder guns (also breechloading and rifled), fifteen machine guns—five in the mast tops and the rest on pedestals, so placed to keep off torpedo boats—and torpedo guns, arranged to fire from five ports, four broadside and one right aft. The outside of the steel hull is covered with two thicknesses of teak (together 6 inches thick), and sheathed on the outside with yellow metal, while the stem, sternpost, rudder, and tube supports are of gun metal.

The character of this metal deserves a special notice. It was found to possess the extraordinary tensile strain of 18½ tons to the inch without breaking, and to stretch 35 per cent. in a length of 8 inches. The plating of the hull varies from ⅛ inch to 7/16 inch, except behind the armor, where it is 1 inch thick. She is three masted, with square sails on all three masts, and has a sail area, in all, of 10,200 square feet, or 13,000 square feet including studding sails. This vessel is divided into fifty-eight water tight compartments; beginning with the double bottom, the subdivision of this consists of no less than sixteen compartments, while vertical thwartship bulkheads at various parts of the hull exist to the number of ten, and longitudinal bulkheads traverse the engine rooms to the boiler rooms; and in addition, the deck flats and armor decks are arranged to act as subdividing the ship

still further, and preventing the spread of mischief, in the event of the vessel being penetrated by shots or receiving external damage from other causes.

The arrangement of inclined armor is made useful for supporting and giving great additional strength to the ram forward, and affords very important protection to the rudder head, tiller, and steering gear aft, which is all arranged to work below it, while cofferdams and similar raised and protected coverings are fitted throughout at all important deck openings, and these openings, on the armor deck, are again protected by strong splinter gratings, as a security against shell.

The engines are by Messrs. Humphrey & Tennant; they are vertical twin-screw engines of the collective power of 6,000 horses. Each set of engines has one high pressure cylinder of 52 inches diameter, placed between two low-pressure cylinders of 74 inches diameter with a three foot stroke and making eighty to ninety revolutions. To insure lightness, cast iron has been superseded by steel or wrought iron or gun metal where advisable. The sole plates for carrying the crankshafts are of wrought iron bolted on to box girders built into and forming part of the structure of the hull. The air pumps are entirely of gun metal, the piston rods and connecting rods of steel, and the propeller shafting of Whitworth hollow fluid compressed steel. The condensers contain 12,000 feet of cooling surface, the tubes being of solid drawn brass $\frac{5}{8}$ inch exterior diameter, the condenser water being circulated outside by means of large centrifugal pumps worked by separate engines.

The pumping arrangements throughout are very perfect, and the centrifugal pumps, and also the fire pumps and air pumps, have bilge connections, so that the vessel can easily be cleared of almost any quantity of water.

There are ten boilers, working at 90 pounds pressure, and containing a total heating surface of 19,400 feet. The shells are made of Siemens steel, all the other parts of Bowling iron. They are located in four separate boiler rooms, each room being divided by longitudinal and transverse bulkheads. Silent blow-off valves are also fitted throughout.

The vessel was designed to insure, with certainty, and when fully loaded and working to full power of 6,000 horses, 15 knots an hour, and to have a coal endurance at that speed for five days' working. This performance was, however, greatly exceeded.

Owing greatly to the fine lines of the vessel and the small resistance offered in passing through the water, it was found that 15 knots was maintained with 4,500 horse power; and from the decreased power found necessary to insure the required speed, and the extra coal economy from the increased expansion that became available, the coal consumption was found to be on a three hours' trial only 1·38 pounds per indicated horse power per hour, and the coal contained in the ordinary bunkers and reserve bunkers, together 800 tons, represented a supply sufficient for twelve days' steaming at 15 knots (and for traversing a distance at that speed of 4,500 miles without recoaling). The details of the trial for coal consumption are annexed in Appendix marked A.

The measured mile speed was equally in excess of the contract requirement, as also was the horse power developed.

The speed was found to be, when working with natural draught, 16·238 knots per hour, the horse power indicated being 6,900 horses, and when working with forced draught under a very slight pressure (only about 1 inch of water) the speed was 16·718 knots, the horse power being 7,300 horses; and in this latter case only eight out of the ten boilers were used (the other two being disconnected.) These measured mile trials will be found in detail annexed (marked B).

The maneuvering power of the vessel was tested in many ways. It was found (1) with both engines working full power on both screws that the entire circle was performed in four minutes and four seconds, and the diameter of the circle was about equal to from two to three lengths of the vessel (see Note C); (2) with one screw and its corresponding engine at rest, and the other working singly, the time of making the circle was only slightly increased; while (3) the inclination of hull was found only to equal 1° to 1½° while performing the circle, the engines working full speed and the rudder being hard over 25°. The speed noted will be observed to be the highest ever attained at a measured mile trial with any ironclad yet built; and, I believe, the coal endurance at the contract speed of 15 knots also exceeds that noted in any ironclad afloat.

In conclusion, I would draw attention to the fact that in vessels of the latest construction in the principal navies—notably those of England, France, and Italy—it will be seen that the development of armor clad ships has resulted in the adoption of a greatly increased tonnage; and that the vessel here referred to, though it cannot be regarded as small, is so in reference to the 10,000 ton, and even 14,000 ton, ships of the navies before referred to; and it may from this point of view be suggestive of the advisability of reverting to more moderate tonnage, which in many ways is desirable; and at the same time insuring results—especially of speed, handiness, and coal endurance—equal if not superior to any yet obtained with the very much larger craft which seems to have been adopted as a necessity in the latest development of fighting ships.

APPENDIX.

NOTE A.—*Coal Consumption Trial, February 15, 1884, between the Nore and North Foreland (Three Hours' Continuous Working).*

Speed	15¼ to 15·3 knots.
Draught of water, forward	19 ft. 4½ in.
" " aft	19·5 "
Steam in boilers, pressure	90 lb.
Vacuum in Condensers:	
Starboard	28
Port	27·9
Revolutions per Minute:	
Starboard	81·5
Port	81·5
Mean Pressure in Cylinders:	
High pressure, starboard	34·34
" port	39·45
Low pressure, starboard	9·18
" port	8·19
Mean Indicated Horse Power:	
Starboard engines	2,251·24
Port engines	2,286·25
Total collective power	4,537·49

Coal consumption for three hours=18,810 lb.=per indicated horse power per hour, 1·38 lb.

NOTE B.—*Measured Mile Trials at Maplin, February 13, 1884.*

Draught forward	19·4½	} 19·4¾ mean.			
" aft	19·5				
With all Contract Weights on Board:					
Midship section	923 ft.				
Displacement	5,700 tons.				
	h. m. sec.				
1st run up	11 41 46	} 3·12=18·750 K.			
90 revolutions	0 44 58				
83 lb. steam			16·066		
2d run down	12 0 48	} 4·29=13·383		16·140	} 16·235 mean.
91 revolutions	0 5 17				
85 S.			16·215		
3d run up	0 17 52	} 3·90=19·048		16 331	
92 revolutions	0 21 1				
91 S.			16 447		
4th run down	0 39 17	} 4·20=13·846			
"	0 43 37				

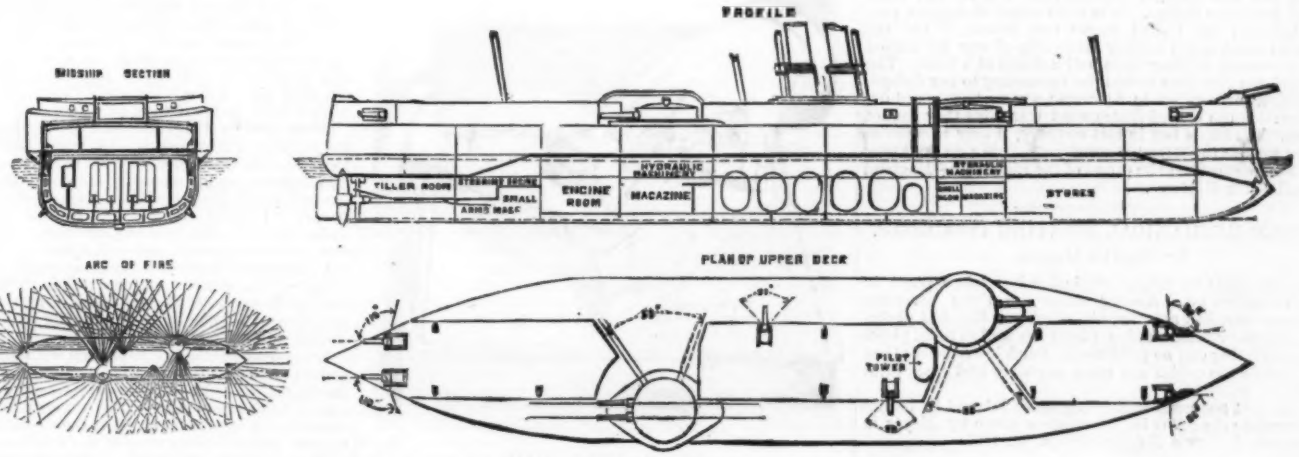
With Natural Draught only.

Second trial with closed stokeholes and forced draught (equal to about 1 inch of water pressure), using only eight boilers (out of ten):

	h.	m.	sec.	
First run up	1	22	4	} 3 min. 18 sec.=18·182 knots.
93¾ revolutions	0	25	22	
92 H. S.				16·718 mean.
Second run down	0	44	1	} 3·56=15·254
	0	44	57	

NOTE C.—*Trials for Time of making the Complete Circle, Engines Working Full Speed*

	h.	min.	sec.	min.	sec.
First to starboard	1	53	3	4	5
	0	57	8		
Second to port	0	59	50	4	4
	2	3	54		



THE NEW ITALIAN WAR SHIP RIACHUELO.

THE RIACHUELO.

IT has been laid down as an axiom that an ironclad ship must be a compromise; and that to obtain anything like a combination of good qualities she must be very large. It has, indeed, been said that it is impossible to produce a satisfactory result with a smaller displacement than 10,000 tons; and the Italian Government build ships with a displacement of 14,000 tons.

The conditions to be fulfilled by a modern ironclad are so complex that it has been difficult to dispute the truth of the propositions we have given above. She must have thick armor, heavy guns, great speed, and be capable of steaming long distances. This appears to be an almost impossible combination of good qualities. The more credit, therefore, is due to the Brazilian officers, who, aided by Mr. Samuda, have succeeded in turning out a craft which really appears to embody the impossible. The more carefully indeed the Riachuelo is considered, the more apparent does it become that Brazil has probably obtained the finest man-of-war in the world, although, within certain limitations, not the most powerful.

We have nothing whatever to compare her with; and if our Government act wisely, they will repair the omission at once. They could not do better than order from Mr. Samuda a couple of ships the precise counterpart of the Riachuelo.

Let us see what this wonderful ship can do. She carries four 20-ton breech-loading guns. These are small compared with the monsters of the Italian and English navies; but they are able to pierce almost any ship we possess, and any ship in the world save a very few. They can send a projectile clean through 18 in. of iron armor, and have some energy to spare.

These guns are so arranged that they can fire all round the horizon. Besides, she has six 70 lb. breech-loading rifled guns, and no fewer than fifteen machine guns. This is a wonderfully well designed and powerful armament. Against unarmored cruisers, for instance, she need not fire one of her big guns; her Nordenfeldts reduce the danger of torpedo attack to a minimum, and she could give a good account of most ironclads. If she were overmatched she could run away faster than any ironclad afloat could follow her, and she could all the while maintain a running fight, for her four great guns can be fired at the same time right astern. Pursuing, no man-of-war could escape by speed; and her guns would as before be available throughout a stern chase. She has two entirely distinct magazines, one for each turret, so that should one-half her armament be rendered useless the other is still serviceable.

Her armor is so disposed as to supply sufficient protection with the least possible weight. She has 11 in., 10 in., and 7 in. armor on her sides. Her breast works and turrets are 10 in. thick, and she has armored decks to render her boilers and engines safe. All this is sufficient to cope with any but very heavy guns. The worst point about her is that when she rolls she may leave a portion of her sides below the belt badly protected.

Her compound engines, by Messrs. Humphreys and Tennant, appear to be about the best ever made; at all events, they have indicated 4,537 horse power for three hours' continuous working, during which the consumption was 1·38 lb. per horse power per hour. With this power she steamed at the rate of over 15 knots an hour. When working with natural draught she has attained a speed of 16·238 knots, with 6,900 horse power, the highest speed by nearly a knot ever attained on the measured mile by an ironclad ship. With only eight of her ten boilers in use, and a very moderate forcing of the draught, she has indicated 7,300 horse power, and attained a speed of 16·718 knots, and we have not the least doubt that with all her boilers under steam, and a forced draught, she would run at a velocity of 17·25 knots, at which speed she could steam round and round any other ironclad afloat.

Now, all this combination of excellent qualities is obtained on a displacement of only 6,100 tons, and this, be it observed, when the ship carries 800 tons of coal, or enough for twelve days' consumption, at 15 knots, during which time she could run 4,500 miles without recoaling. No ironclad afloat can compare with her in coal endurance.

These admirable results are due mainly to two factors. The first is the enormous power of Sir William Armstrong's guns, and the second the excellence of her machinery. A very few years ago the 20-ton gun was a comparatively feeble weapon. It is 9 in. in diameter, and it was held to be just capable of piercing iron armor at the utmost 10 in. thick. The new 20-ton steel gun is really almost three times as powerful as the old gun—a result which is due to its great length and the enormous powder charge which it can carry, thanks to the enlargement of the powder chamber. It is, however, when we turn to the machinery that we find the great factor in the solution of *the* problem of naval construction.

The engines are apparently the most economical ever sent to sea; and it is for this reason that the ship can steam so far. That she can steam fast as well is due to the beautiful lines of the hull, which are more like those of an Atlantic racer than those of an ironclad.

Mr. Samuda showed a fine model of the ship during the recent meeting of the Institution of Naval Architects, and from this it can be gathered that the ship, like the princess in the fairy tale, is as beautiful as she is good. Indeed, it would seem that we may yet have fleets of handsome ironclads. Some doubt was cast on the economical performance of the engines during the meeting of the Institution of Naval Architects. Nor is this to be wondered at. But the coal was weighed by the Brazilian authorities, and the indicator diagrams were taken by engineers of our own navy. There is therefore no reason to doubt the perfect trustworthiness of the statement made by Mr. Samuda. The doubt is, of course, that the fires were in precisely the same condition at the beginning and end of the three hours' run; but with care it would be easy to reduce the chance of error arising in this way to a small factor. Even, however, if we make a considerable allowance, and take the coal consumption to be 1·5 lb. per horse per hour, it will detract but little from the marvelous steaming powers of the ship, the great distance which she can traverse being due in one respect to the high rate of speed which she can attain. If we suppose her speed to be reduced to 12 knots—which is nearly the highest speed of many crack ironclads—it will be seen that she could run continuously without recoaling a distance of no less than 8,700 miles. This would take her to Australia from England

with once coaling. We do not possess a man-of-war of which this can be said, because we have no engines afloat so economical, no ship with so small a resistance. Too much importance cannot be paid, we think, to giving men-of-war such shapes as will secure the best possible coefficients; but unfortunately few ironclads are designed for speed, although it is the highest quality such ships can possess, giving them, as it does, the key of any position in which they may be placed, and enabling them to adopt just that style of fighting which suits them best. The high economy of the engines appears to be due in great part to the fact that the boilers are large enough to supply plenty of steam without unduly urging the fires She has 19,400 ft. of heating surface, or 4·3 square feet per horse power at 15 knots—an unusually large proportion. The grate surface is not given in Mr. Samuda's paper; but, assuming it to be one twenty-fifth of the heating surface—a very common proportion—we have a total of 776 square feet; and for a total consumption of 6,300 lb. per hour this gives a consumption per square foot of grate per hour of only 8 lb. Under these conditions it is probable that the boilers evaporated not less than 11 lb. of water per pound of coal, so that the steam used per horse per hour was 15·18 lb.—a possible but extremely low consumption.

We cannot take leave of the Riachuelo without commending her to the attention of the United States Government, and we would ask the Naval Advisory Board, or its ex-members to compare her with the Chicago. This vessel we have fully criticised already, and described and illustrated. It will therefore suffice to say here that the American cruiser is to have a displacement of 4,500 tons, or only 1,300 tons less than that of the Riachuelo; and in not a single feature does she compare favorably with the latter. The Chicago is to be propelled by twin screws, and she is allowed 18,518 square feet of heating surface, 6,000 square feet of superheating surface, and 800 square feet of grate—nominally more boiler power than that of the Brazilian ironclad. Yet she is expected to develop only 4,800 horse power, and have a maxium speed of but fifteen and a quarter knots while her bottom, which is not to be coppered like that of the Riachuelo, is clean. Her bunkers will stow 800 tons, the same quantity the Riachuelo carries, but she will only be able to keep the sea for six and a half days, and to steam but 1,950 miles. She could not cross the Atlantic. Her armor and her armament cannot bear comparison with those of the Riachuelo; while it is more than probable that she will cost at least as much. The two vessels supply an admirable illustration of the arguments which we have advanced—namely, that to design a good ironclad requires some experience; that no one in the United States possesses this essential; and that much better results could be got by copying the best English practice than can be had from original American design. It is to be hoped that peace may reign between the United States and Brazil; if not, the Riachuelo alone could destroy every ship of war the United States possesses, fighting them half a dozen at a time. The doings of the Alabama would be as nothing to her doings; and no Kearsarge exists in American waters that could destroy her. If the United States want war ships they cannot do better than buy a few in this country, if only to serve as patterns for use in their own navy yards. We do not know which has most cause to be proud of the Riachuelo—England or Brazil.—*The Engineer.*

CHEMICO-MECHANICAL PRINTING PROCESSES.

By HERMAN MEYER.

IN recent times an actual revolution has taken place in the reproductive art. Among these are three processes which may be called autographic, chemigraphic, and phototypic, whereby lithographic plates as well as relief plates for type printing can be produced at much lower prices than before, while the copies are more accurate and the print cleaner.

The subject possesses sufficient general interest to induce us to translate the following description given by Meyer in the *Deutsche Industrie Zeitung* of Sept. 12, 1883:

THE AUTOGRAPHIC PROCESS.

In this process the drawing is made with greasy ink and transferred to stone or zinc by laying the drawing upon it face down and running both through a press. A smooth paper and a granular paper with a chalk surface are sold especially for this use. Drawings are made on the former with a pen and prepared ink, while autographic chalk is used on the latter, but it must not be washed. Both substances are greasy. It is all transferred to the zinc or stone, and then treated like an ordinary lithographic drawing.

The principle underlying the lithographic process is that when a roller covered with fatty ink is rolled over the plate, the ink only adheres to the lines of the drawings, for they alone are greasy. Then on covering the stone with a sheet of clean paper and running it between two rollers, the ink prints off on the paper.

The advantages of the autographic process are that it saves *one* drawing. A very accurate drawing has to be made for the lithographer to copy, and that costs nearly as much as the drawing on stone, and then it is often difficult to avoid some mistake or misunderstanding in the copy that the lithographer makes, as he does not understand the subject so well. Now the drawing can be made under supervision and the draughtsman can penetrate the object. He must, of course, work very accurately, for it is very difficult to make any changes and corrections, but this does not offer any more difficulty than in ordinary lithography, for single objects can be erased from the stone and then redrawn and printed on again.

The limitation to the use of chalk is the fineness of the grain. If not every draughtsman has full control of the material, still a dilettante who knows how to draw with chalk can make the drawing himself, and thus effect a considerable saving in expense. Pen-drawings are to be preferred for fine work, but for other work chalk is to be preferred, yet a combination of pen and chalk on grained paper does not give satisfactory results. In making the drawing the greatest neatness must be observed, for a slight imperceptible spot of grease or a drop of saliva will be reproduced in black.

ZINCOGRAPHY.

There is a great saving of money and time effected in preparing relief plates for letter-press printing, as wood engraving is a very tedious and costly process. The process known as zincography consists in making a relief of zinc instead of wood, so that when an inking roller is passed over it the raised portions take the ink so that it can be printed in a common press. A drawing is made as above described with a fatty ink, and then transferred to zinc instead of stone. Very fine asphalt dust is sprinkled over it, and adheres to the ink; then on warming the plate the asphalt melts and runs, forming a protecting film, so that a slight relief is obtained by carefully etching it in dilute sulphuric acid. By rolling this with a fatty ink, dusting it with asphalt again, and repeating the etching, the relief is raised a little higher, and the process is repeated until the desired height is obtained.

The author says that plates prepared in this way in Vienna cost only 8 cents per square inch, a price astonishingly low compared with wood engraving. The limitations to this process are the same as for the lithographic. In many cases the method is perfectly satisfactory, and gives excellent results.

PHOTOTYPES.

For finer drawings, and especially for artistic work, a photo-relief process called a phototype is used. Although this costs twice as much per square inch, with $1.00 or $1.25 extra for the negative, it is still cheaper than wood engraving, and gives the most perfect results imaginable.

The original drawing is transferred to the zinc by photography, and forms the first protecting film. The etching is performed as in the previous process. The original drawing remains uninjured, and any drawing that does not consist of intermediate shade and tints, like India-ink pictures and photographs, but possesses a certain grain or is made in line, can be transferred in this way. In the same way engravings and wood-cuts can be reproduced very cheaply and with any desired reduction. A reduction of about two-thirds is generally advisable.

Although any suitable picture, such as crayon, chalk, pencil, or pen and ink sketch, engraving, or wood-cut can be reproduced in this way, still it is advisable, when a drawing is made expressly for this purpose, to make it large and shade it more heavily, as the shading looks fainter when it comes to be printed.

HOW TO WORK THE NEW COPYING PROCESS.

THIS process consists in transferring to a pad or tablet, composed essentially of a gelatinized solution of glue in glycerine, writings made on paper with a strong solution of one of the aniline dyes—violet or blue being generally preferred—and from this obtaining duplicate copies of the original by simply pressing sheets of paper on the transfer. The *modus operandi* of the copying is given briefly as follows:

Write with a steel pen on ordinary writing paper; allow to dry; press the writing gently upon the tablet; allow it to

NEW COPYING PAD.

remain a minute, when the greater part of the ink will have been transferred to the gelatinous surface, and as soon as the paper has been removed the tablet is ready to take impressions from. Place ordinary writing paper upon the charged tablet, smoothing over with the hand, and immediately remove the sheet, which will be found to bear a correct copy of the original writing; repeat with other sheets until the transferred ink becomes exhausted. Immediately after, wash the tablet with water and a sponge, let it dry, and it is ready again for use.

With a tablet and ink prepared according to the following, fifty good copies from one transfer have been obtained, and doubtless with care it would afford twice this number. The proportions for the pad or tablet are: Gelatine, 1 ounce. glycerine, 6¼ fluid ounces. Cooper's gelatine and pure concentrated glycerine answer very well. Soak the gelatine over night in cold water, and in the morning pour off the water and add the swelled gelatine to the glycerine heated to about 200° Fah. over a salt-water bath. Continue the heating for several hours to expel as much of the water as possible, then pour the clear solution into a shallow pan or on a piece of cardboard placed on a level table and having its edge turned up about ½ inch all around to retain the mixture, and let it remain for six hours or more, protected from dust. Rub over the surface a sponge slightly moistened with water, and let it nearly dry before making the first transfer. The ink is prepared by dissolving 1 ounce of aniline violet or blue (2 R B or 3 B) in 7 fluid ounces of hot water, and, on cooling, adding 1 ounce of wine spirit with ¼ ounce of glycerine, a few drops of ether, and a drop of carbolic acid. Keep the ink in a well stoppered bottle.

NICKEL PLATING ON ZINC.

By Prof. H. MEIDINGER.

SUCCESSFUL electroplating in general depends upon three conditions: on the quality and properties of the metallic solution (the bath), on the strength of the current, and its relation to the surface of the pole, which determines the thickness of metal deposited in a unit of time (rapidity of precipitation), and on the nature of the surface of the pole on which the metal is to be deposited. If the pole is of metal and is to be inseparably united with the deposit, as is the case with silver plating, the surface must be perfectly clean and free from oxide or grease. If the surface is dirty, the precipitate peels off. It will not adhere at all to non-metallic substances, but merely inclosen them.

It is a fact worthy of attention that under otherwise similar conditions many metals do not take certain deposits well. In some cases the deposit is streaked, powdered, or of bad color, and in others it peels off afterward when polished. Iron in its different forms (steel, wrought iron, or cast iron), zinc, lead, and tin cannot be readily silvered or gilded in the cyanide bath, although it works first rate on copper and its alloys, and is generally used for that purpose. But of the copper alloys German silver causes more difficulty than brass. Copper, brass, and iron are easily plated in the nickel bath; zinc, on the contrary, is not. In some of these cases the metal to be plated acts directly on the solution itself, as, for example, zinc acts on silver and nickel solutions, and this circumstance may effect the properties of the whole deposit; this does not happen with iron.

If a metal cannot be nicely plated in a bath, it is customary to cover it first with some other metal of better quality in this respect. Thus iron, zinc, and tin are easy to silver and gold plate after they have been copper plated, and zinc can also be nickel plated under these conditions.

To unite the deposit as firmly as possible with the object, it has been found in many cases advantageous to slightly amalgamate the surface of the metal to be plated, especially in giving a thick coating of silver to instruments. The method is extremely simple, for it is only necessary to dip the articles for a short time into a mercurial solution and then rinse them with water.

The quantity of mercury used is insignificant, in fact a heavy amalgamation must be avoided, as it would make the metal brittle. A mercurial solution serviceable for this purpose is made with the commercial mercuric nitrate or chloride (corrosive sublimate). The solution must be very dilute, about one, five, or at most ten parts of the dry salt in a thousand parts of water; to this solution some sulphuric or chlorhydric acid is to be added until the liquid is perfectly clear. The stronger solution gives up more mercury in a given time than a weaker one, and this must be taken into account in amalgamating. With practice it is easy to tell from the change of color when enough mercury has been deposited. Iron does not alloy, or only very badly, with mercury, and hence it cannot be subjected to the process just described.

Within the last decade nickel plating has reached an extraordinary development. At first it was limited to iron, then it was gradually extended to brass and German silver, and now is increasing in favor for coating zinc. As this metal takes the nickel from ordinary baths very badly, it has been proposed to copper-plate it in the cyanide bath. But this is a nuisance. The use of the poisonous cyanide bath should be avoided as far as possible, and limited to cases where it cannot be dispensed with; in nickel plating, cyanides are not absolutely necessary, even if an intermediate layer of copper is desirable in thick nickel plating. The cyanide of copper (and likewise brass) bath has a disagreeable property of only working when certain conditions are exactly observed; it also decomposes easily. As the nickel wears off by use the red shines through, which is worse than if the white zinc itself were laid bare. Experience also showed that coppered zinc, when it came into the nickel bath, at once turned black and could not be plated.

There is not yet any literature on amalgamating zinc for the purpose of nickeling it. On many sides objections are heard against the deficiencies of the customary process of nickel plating, and it seemed to me worth while to make some experiments in this direction. The experiments were satisfactory. I amalgamated a sheet of zinc, and then had it nickel plated by Schwerd in Carlsruhe. The nickel adhered well, united perfectly, and took a fine polish. I think it is not improbable that the nickeled sheet-zinc of commerce is prepared in a similar manner. This supposition receives support from one of the properties of this zinc to which my attention was called by Beuttenmüller, who has used a good deal of it in his factory.

It is rather brittle in comparison with pure sheet zinc. I cannot explain this brittleness in any other way than due to amalgamation. The alloys of mercury with solid metals, called amalgams, exhibit this property—that the mercury dissolves off small quantities of the metals to form a thicker liquid; with a larger excess of the solid metals the alloys are solid, but fragile and brittle. This character remains, but grows gradually less. When a sheet of metal is amalgamated, it depends on the quantity of mercury combined with it and the depth to which it penetrates, whether it will cause a perceptible change in the strength of the metal.

Copper must remain in contact with mercury for a long time until it has penetrated a considerable depth; with zinc this takes place very rapidly. A sheet of zinc one millimeter in thickness, thoroughly cleansed in acids, only needs to have metallic mercury poured over it so that it forms a bright mirror to make it so brittle that it will not stand bending. Zinc carries this peculiarity into its alloys with copper, so that brass and German silver are much more sensitive to mercury than copper. If zinc is immersed in a mercurial solution, it will depend upon the time it stays in whether the mercury will be merely deposited upon the surface or will penetrate more deeply into the zinc. A concentrated mercurial solution will make a sheet of zinc one millimeter thick brittle in a few minutes.

The quantity of metal necessary for nickel plating will have an imperceptible influence on its strength if the zinc is thick; but if it is thin it may show a perceptible difference, which makes it difficult to work the zinc. Special care must be taken to prevent too much mercury being deposited on the zinc by leaving it in the solution too long. The exact quantity can only be determined by experiments that are simple and easily carried out.

When one metal is deposited on another by the galvanic current, we cannot speak of them as alloys if they are inseparable, for they are only held together by adhesion. Hence there can be no change in the characters of the two metals; neither a harder nor a more brittle product results from electroplating. If the latter is observed, even in a slight degree, it is easy to conclude that there is mercury in it.

Pure zinc has a different action on nickel solutions from amalgamated zinc. The former soon turns yellow and brown, and the deposit can be rubbed off with a piece of paper. If a feeble current is employed this chemical action preponderates, and hence we obtain a poor deposit. If the current is very strong, the zinc will be more rapidly coated with nickel by electrical action than it would by the chemical action of zinc on the solution, and a good deposit can be obtained. It is only by observing these precautions that it is possible to nickel plate zinc directly, and yet this is frequently inconvenient. If amalgamated zinc is dipped into a nickel solution, after a long time feeble action will begin. The mercury, although there is so little of it, protects the zinc against the action of the liquid, as zinc in its alloys with copper, brass, etc., is protected against the attacks of different liquids, copper sulphate, sulphuric acid, etc. Yet in all these cases the protection is incomplete; after a while a

slight action is observed. In nickel plating zinc, slight amalgamation will suffice to secure a good deposit with a feeble current.

It has been observed that some kinds of German silver take nickel badly; previous amalgamation may, perhaps, be an advantage here too.—*Badische Gewerbe Zeitung.*

OLEUM GAULTHERIÆ—OIL OF WINTERGREEN.

By ISAAC EDWARD LEONARD, Ph.G.

OIL of wintergreen was first made in Luzerne County, Pa., in 1863, from which time it has been distilled in great quantities, with the exception of last year, when the yield was not so plentiful, owing to the destruction of the shrubberies by the fire which passed over our mountains.

In distilling, the entire overground portion of the plant is employed, which has its greatest yield during the months of July and August.

The still is generally a wooden box, about 8 feet long, 4 feet wide, 4 feet high, with a copper bottom and stayed with bolts. The head of the still is copper, and connecting with this is a square or circular worm of the same material or of tin, placed in a barrel. The still being filled with wintergreen to within about 12 inches of the top, a sufficient quantity of water is added, and this is allowed to macerate from ten to twelve hours. The fire being started, the distillation commences and continues for about eight hours; but during the first two or three hours, 90 per cent. of the oil has passed over. For collecting the distillate, most of the stillers use a wide mouth bottle or fruit jar, fitted with a large cork having two holes. A small tin or glass funnel is put into one of the holes, so that the beak of the funnel is below the shoulder of the receiving vessel, and connected with the other hole is a suitable pipe forming an egress. The distillate passes into the receiving vessel through the funnel. It is here that the oil and the water separate, the oil going to the bottom, and the water, being lighter and in excess, passes through the egress pipe into a larger receptacle, where it is reserved for a subsequent operation (cohobation).

Occasionally the oil is very highly colored. I have found several samples to contain traces of iron, which is due to the oxidation of the tin worm or can with which the oil comes in contact. Tin worms are used on account of their cheapness, but will only last about two weeks before they undergo oxidation.

The wholesale dealers that handle the oil in large quantities have three ways of "cleaning" it: redistillation, filtration, and decolorization. The first two processes are easily understood, while the decolorization seems a difficult one, but is much easier than either of the others. The oil to be decolorized is put into a bottle, and crystals of citric acid are added, the whole allowed to stand, agitating occasionally, until the oil is colorless, or nearly so.

On experimenting with nine quarts of wintergreen fruit, I found it contained one and one-half drachms of oil. The chief uses of the oil are for flavoring and in printing fine calicoes.

In experimental distillation, I found that the lower specific gravity is due to the separating of the oil from the water too quickly, and that the higher specific gravity is obtained by letting the distillate stand from twenty-four to forty-eight hours before separating the oil from the water.

THE GASES SUPPLIED TO NEW YORK.—THEIR MANUFACTURE AND COMPOSITION.

THE recent effort made to inspect the character and manufacture of water gas, accompanied with an associated design upon the other gas companies, may awake at least some intelligent desire in the public to know what are the sorts of gas at present furnished in the city, and the processes by which they are made.

About six months ago there were four processes employed by the seven companies which supply New York city with its light, and the resultant gas from each possessed its peculiar constitution, advantages, and disadvantages. One of these processes has, I believe, been abandoned, but the explanation of the four then used, will adequately suggest the divided sources whence we are supplied with gas.

First in order by reason of its antiquity, and the prominent defense made for it by the representative gaslight company of the city—the Manhattan—comes the coal gas, made by the distillation of bituminous and cannel coals. These rich and hydrogenous bodies when inclosed in hermetically sealed vessels—the clay retorts of the present gas houses—and exposed to high heats ranging from 1,200° to 1,500 Fah., yield large quantities of volatile materials, which ascend from them in a mixed state, and it is the design of the subsequent steps in gas making to separate this unsalable mixture into a number of component bodies, of which the gas is the last and most valuable. Or putting it more literally, it is the duty of a gas engineer to free the gas from the presence of all hurtful or useless bodies which are mingled with it upon its ascent from the retorts where it is generated.

The volatile bodies arising from such a charge of bituminous or cannel coal are very numerous, and vary according to the character of the coal employed and the degree of heat. It is unnecessary to enumerate them, but they form a great number in the aggregate, besides a large amount of tarry matter which is volatilized at the high heat, only to be carried a short distance, when, after cooling, it is deposited and forms the tar of gas houses, a residual of the deepest interest scientifically, and commercially quite valuable. This indefinite and varying mixture of vapors, gases, and volatile salts can be considered as composed first of the necessary elements of the commercial gas, secondly of the gases which, while unavoidably accompanying the finished gas, are unnecessary, viz., the diluents of the gas, and thirdly, the impurities which must be removed to render the gas pure, so that it can be easily and safely burned.

Let us step into a gas house, and notice some of the steps by which this is accomplished. We open the door of a long rectangular structure, along whose open roof pour mingled clouds of vapor and smoke. We enter, and meet an interesting scene. Down the center of the wide and lofty room extends a solid mass of brick masonry, in which the clay retorts, where the gas is first formed, are embedded. These clay retorts are ⏢ shaped, 10 feet long, and mounted upon supports of fire bricks, in sets of 5. Each set is exposed to the flames arising from a furnace beneath, which is either a simple coke furnace or a generator furnace of new and skilful construction, intended to supply the heat necessary for the distillation of the coal with greater uniformity and more cheaply.

Each retort is charged with about 200 lb. coal, which is inserted upon an iron, gutter-shaped scoop, and after four hours the retorts are opened, and the coke, left in the retort, withdrawn. The perspective down the long face of retorts which are being charged and "drawn," with the mouths of some encircled by tongues of flame, while clouds of steam and wreaths of smoke ascend in cyclonic curves around the titanic forms of the bare-armed dusky, and sweating stokers, forms a picturesque and striking picture. Three of these strong men seize the iron scoop, two on the sides, and one at the handle, and lifting it up together rush forward toward the open mouthed retort; the end of the scoop is inserted, and by a dexterous and rotatory motion thrust to the end, overturned, and withdrawn. The retort is then quickly luted, or closed with its iron mouth piece, and the charge left. When the retort charge has given off all its gaseous contents the men approach, unlute the mouth piece, apply a lighted paper to the remnant of gas that issues into the air. It flashes into flame with a slight explosion, and pours upward a volume of smoke; the glowing heaps of coke are seen within the long retort, with the unsteady motion of the heated air rising over them.

This coke is withdrawn by a long hoe-like instrument, and it falls into cellars below, where it is cooled by water being thrown upon it, and carted away. From the retorts, the gas and mingled products pass into the hydraulic main, a long iron trough where the heavy condensable tarry particles drop out, forming a viscous, flowing body, which is the gas tar. The gas is still very hot, and loaded with condensable vapors, etc. To cool it, it is passed through a series of upright tubes of iron in contact with water, where it is cooled down to somewhere about 70°. The impurities are now to be removed, and they consist principally of ammonia salts, sulphur compounds, and carbonic acid.

Then it passes through an operation, very frequently divided into two steps, and also often combined into one, viz., washing and scrubbing. The scrubbing takes out fine particles of tar; this may be omitted, if the previous condensing has been very perfectly effected. It is usually accomplished by forcing the gas through a dense pile of birch brush or lattice work or coke piles. Water trickles down over these, and absorbs part of the ammonia salts. High towers with water sprays falling down them over woodwork or revolving disks of iron in water complete the removal of the ammonia. The gas freed from ammonia passes through boxes of wet lime, so disposed that the most impure gas meets the lime box most soiled. The gas parts here with its sulphur compounds and carbonic acid, then its volume is measured by enormous meters, it is passed into the great cylindrical holders which attract so much attention from the streets upon which they are placed, and is ready for delivery to the consumers.

The gas finished has about the following composition, it itself being a mixture of seven other gases, some of which are not always present:

ANALYSIS OF MANHATTAN CO.'S GAS BY DR. E. G. LOVE.

Hydrogen	45·79
Marsh gas	39·01
Carbonic oxide	6·31
Illuminants	6·38
Nitrogen	2·51
Carbonic acid	—
Oxygen	—
	100·00

The sulphur in gas should not exceed 20 grains per 100 cubic feet, the ammonia not 5 grains per 100 cubic feet, and there should be no carbonic acid nor sulphureted hydrogen. The former destroys the illuminating power, the latter is injurious. The candle power is taken constantly at the works, and affords a convenient index of the character of the gas. It is not necessary to enter now into an explanation of this test, but simply to say it consists in finding out how many standard candles the light of five feet of gas equals. This number is called the candle power, that vexatious and cabalistic utterance of gas men. In ordinary coal gas it varies from 16 to over 20.

Coal gas made in this manner is supplied to New York by two companies only, the Manhattan and Harlem.

A modified form of coal gas manufacture is in use at the works of the Metropolitan Gaslight Co. The light giving ingredients of this gas are added to it by petroleum naphtha, which is introduced into separate retorts by means of an iron tube, telescoped in a series of lengths of wider pipe, until at the further end from the mouth of the retort the oil escapes as vapor and returns the entire length of the retort to the mouth again, exposed to the high heat of the sides. This converts it more or less into a permanent gas, and it then passes on through a treatment similar to that employed with the coal gas. The coal gas made by this company is of an inferior quality, but is enriched by this oil gas and made a very excellent product.

The gas has the following composition as analyzed by the writer:

Hydrogen	38·50
Marsh gas	41·00
Carbonic oxide	8·50
Nitrogen	4·50
Oxygen	—
Carbonic acid	—
Illuminants	7·50
	100·00

It has a candle power of about 23 ranging under and above this.

The water gas which has been introduced within the last five years into quite extensive use in New York is itself no new discovery; the chemical laws involved in its formation were known 50 years ago, but the present process of enriching it with light-giving bodies is comparatively recent, and the method of its manufacture has been considerably modified.

The process employed in the city by the companies furnishing this style of gas is substantially as follows: Large iron furnaces lined with firebrick, and technically designated as *gasogens*, are filled with anthracite coal, which is fired, and by suitable air blasts brought up to a very high heat; into this glowing mass superheated steam is injected, which, encountering the white-hot coals, is shattered, as it were, into its components, hydrogen and oxygen; the oxygen combines instantly with the carbon of the coal, forming carbonic oxide and carbonic acid, and the hydrogen remains unchanged. This rapid decomposition of the steam absorbs an immense quantity of heat, and in ten minutes' time the steam is turned off, as the coal is cooled too much to permit further action; the air blasts again heats up the mass, and the steam blast succeeds it, and so with an intermittent action the gas is formed, which has almost no illuminating power. It may be added that marsh gas, oxygen, and nitrogen, and ammonia and sulphur compounds accompany the gas to some extent.

This gas is enriched by passing over trays of naphtha in a hot water jacket, which saturate it with illuminants. But these would drop out or condense in the cold, and to *fix* them as gas, the mingled gas and vapor is passed through retorts kept at a certain heat which decomposes the naphtha vapor into marsh gas and light giving bodies.

After purification the gas is ready for use. Its characteristics are high illuminating power and a high percentage of the poisonous component, carbonic oxide. Its composition is as follows:

ANALYSIS BY DR. E. G. LOVE.

Hydrogen	26·25
Marsh gas	28·91
Carbonic oxide	27·12
Illuminants	15·80
Carbonic acid	—
Oxygen	—
Nitrogen	1·92
	100·00

The writer has experimented upon its poisonous qualities, and found some years ago, that with equal amounts of Metropolitan and Municipal gases in a cubic foot of air rats lived five times longer in the former than in the latter. Of course, as the percentage of either was greatly increased, the difference would be far less marked, and it would seem that ordinary precautions would never allow this poisonous ingredient to work much harm. From analyses made later than the above by the writer, the carbonic oxide appears to have been diminished. The candle power of the gas varies from 28 to 30, and sometimes falls below the former number.

This gas is furnished to New York by the Municipal, New York, and Knickerbocker Gas Light Companies.

The last process of making this indispensable article was used by one company only in New York, the Mutual, and has, I believe, been abandoned.

It consisted in distilling wood instead of coal in clay retorts. Virginia pine was used, and about 47,000 cubic feet of crude gas was obtained from one cord of wood. This is a very poor gas, and was enriched in a manner almost identical with that described for water gas.

Its composition when finished and ready for sale was:

ANALYSIS BY DR. E. G. LOVE.

Hydrogen	12·75
Marsh gas	39·21
Carbonic oxide	12·33
Illuminants	15·22
Nitrogen	19·36
Carbonic acid	0·89
Oxygen	0·24
	100·00

A water gas has since been substituted for the above by the Mutual Company of a candle power of 25 to 28.

The introduction of water gas and naphtha-enriched gases has increased the quality of the product, and necessitated high pressures, both to enable the consumer to burn enough and to render the combustion of the flame smokeless. The statement made recently to a reporter of the *Evening Post* that gas bills had increased on account of the greater lightness of the water gas is absurdly false, as the gravity of coal gases, taking air as unity, averages 0·430, while the gravity of enriched water gases ranges from 0·620 to 0·660. Larger burners and a more lavish use of gas on the part of consumers are the more likely causes of this unpleasant improvement in gas bills.

The districts supplied by the various companies are outlined as follows: The New York, below Grand Street to the Battery; the Mutual runs its pipes also in this region. The Manhattan, from Grand to 34th Street. This region is intersected by the mains of both Mutual and Muncipal. The Metropolitan, from 34th to 79th Street. Through this territory the Muncipal and Mutual companies supply their own consumers. Above 79th Street through Harlem, the Harlem Gas Company furnishes the most of the gas consumed, though they encounter the mains of the Knickerbocker at many points.

Some idea of the amount of capital put into mains may be formed from the tabulated statement of the lengths of gas pipe possessed by the several companies in the city:

Companies.	Miles of mains.
Manhattan	173
Harlem	118
Metropolitan	130
N. Y. Mutual	118
New York	110
Municipal	95

L. P. G.

OXIDATION OF SULPHUR COMPOUNDS.

By DR. G. LUNGE.

IN presence of an excess of soda, sodium sulphite is transformed during concentration into hyposulphite, by the action of the atmospheric oxygen alone. If the lye at the moment of causticification is agitated by means of a current of air, the sulphide disappears entirely. But, subsequently, when the concentration has raised the boiling-point to about 140°, the hyposulphite splits up into sodium sulphide and sulphite. The former may be again oxidized by the same process, and the cycle of reactions be repeated, all the sulphide may be converted into sulphite; but this change, at temperatures below 360°, requires a very long time. Sodium sulphite is oxidized by the air to sulphate, the more rapidly the higher the temperature; at a red heat the introduction of a current of air converts all the sulphide into sulphate. Sodium sulphide may also be oxidized by means of niter. The reaction begins below 140°, and if the oxidizing agent is not in excess, which is always the case in practice, it is entirely changed into nitrite.

This body subsequently reacts upon the sulphide, not yet attacked, and converts it into sulphite. There the reciprocal action ends, the sulphite and nitrite remaining in presence of each other up to nearly 360°. At this temperature sulphate is formed with liberation of nitrogen. The action of nitrate never produces hyposulphite. That which is formed in the crude caustic lyes is produced at the expense of atmospheric oxygen. The hyposulphite is relatively very stable. The niter passes at first into the state of nitrate, which, in presence of oxidizable sulphur, is totally reduced with liberation of ammonia.

This reaction begins at about 140° in iron vessels. Along

with the production of ammonia, which reaches its maximum at 180°, and still continues above 300°, the formation of free nitrogen is observed. The maximum useful effect with niter is obtained by causing it to react at a low temperature. We are thus led to the following rational procedure:—The sulphide is first oxidized to hyposulphite by means of atmospheric oxygen. As the hyposulphite is only oxidized slowly by the air when the temperature has reached 140°, there is no splitting up into sulphide and sulphite. It is well not to add the niter until the temperature has risen to the decomposition point into sulphide and sulphite, and to introduce it then by small quantities. In practice the first dose of niter is added as soon as the presence of sodium sulphite is detected in the liquid, and the last portions about 300° to 360°.

CETEWAYO.

ALTHOUGH nominally called "Prime Minister," Cetewayo was virtually king of Zululand for many years before the

CETEWAYO IN ENGLISH DRESS.

death of his father, Panda, which took place in 1873. In that year Cetewayo was crowned in the presence of the British Secretary for Native Affairs, Mr. (afterward Sir T.) Shepstone. Some years after, in 1878, Sir Bartle Frere, Governor of Cape Colony, put forth that memorable declaration, which has been the source of incalculable misery and misfortune, that Cetewayo's military power was a menace to Natal and the Transvaal. War followed. The Zulus fought like heros. They beat us at Isandlana; we barely held our own at Rorke's Drift; we beat them at Ulundi. Cetewayo fled, was captured, and detained in honorable captivity at Cape Town. He longed to come to England to lay his case before the Queen. His prayer was granted, and he was reinstated. But the restoration was effected in a half-hearted fashion; he was supported by no British force, and consequently John Dunn and the other kinglets who had been appointed in his absence revolted against his authority, a bloody war took place, Cetewayo fled wounded to the bush, and, when he emerged, had lost all his old influence. He was induced by the Natal authorities to come and live in the "Reserve," but they declined to grant him the independent inquiry which he demanded. He had already shown symptoms of heart disease, and no doubt the anxieties and misfortunes of his latter days hastened his end. He died February 8, 1884, in his camp at Eshowe.

Our large engraving is from the London *Graphic*. The portrait is from the *Missionary Herald*.

DR. RAINER RITTER VON SCHMERLING.

ON the 10th of March of this year, Dr. Rainer Ritter von Schmerling celebrated the fiftieth anniversary of his receiving the degree of Doctor of Medicine from the University of Vienna. In the large hall of the Imperial Academy of Science, Dr. Von Schmerling received representatives of the scientific world, the highest officials of Vienna, representatives of the College of Physicians and Surgeons, and of other corporations of physicians. The festivities were closed by a banquet in the Cursaion.

Dr. Von Schmerling is special physician to the Archduke Albrecht of Austria. He is president of the Vienna College of Physicians, and possesses numerous foreign orders of high standing. After passing his examination as physician, he served for two years as assistant physician in one of the Vienna hospitals, and then studied for a number of years in foreign hospitals. In 1842 he received his appointment as physician to Prince Albrecht, with whom he has been ever since. During the years 1849, 1859, and 1866 he devoted most of his time to the care of the wounded soldiers in the hospitals of Vienna.—*Neue Illustrirte Zeitung.*

POISONOUS PIGMENTS AND WALL PAPERS.

ABOUT a year ago the National Health Society solicited Earl Granville to instruct the representatives of the Foreign Office abroad so that they might obtain reports respecting foreign enactments for the limitations, restrictions, or safeguards in the manufacture, use, and sale of arsenical and other poisonous colors used for wall papers and other decorative purposes. A circular was accordingly addressed to the representatives by his Lordship. The reports which were received have been printed, and will be found interesting to sanitarians. The following abstract will suggest the state of opinion on so important a subject;

In Austria there is no direct prohibition against the production of arsenical and other poisonous pigments; but the manufacturers require a license and special permission for the establishment of such a business, and precautionary measures have to be adopted by them for the protection of the workmen. The Austrian authorities are considering certain proposed stipulations by which the employment of colors made of arsenical substances will not be allowed in artificial flowers, wall papers, colored paper, and dressing stuffs, and the importing of all articles in which arsenical pigments are used is to be illegal. An Imperial law was passed in Germany in 1879, in order to regulate the sale of all articles containing poisons, but there has been more or less uncertainty about the interpretation of some of the enactments. A committee of the Reichstag have recommended that the words "prepared with arsenic" should be used instead of the words "containing arsenic," as by this means colors only to which arsenic had been added would be forbidden, whereas others containing very slight blendings of arsenic through accidental circumstances, such as earth colors, would be permitted. In the decree of the Emperor which came into force, it is accordingly ordained that the use of "colors prepared with arsenic" is forbidden in the manufacture of paper hangings. The punishment for contravention is severe, and, in case of severe bodily injury or death to a human being, it may extend to five years' penal servitude. The Imperial law in no way interferes with the regulations which have been adopted in the several States. In Baden not only are arsenical wall papers illegal, but there is a prohibition against the tinting of walls or ceilings of dwelling houses or factories with arsenical compounds. The Hessian police code imposes a penalty of from one to thirty florins on any person who, for the purpose of furnishing or covering the walls of any dwelling-room, employs paints, wall papers, or stuffs tinted with any of the pigments which are designated as "injurious to health," such as Scheele's green, Schweinfurth green, and King's or Naples yellow, and all colors containing arsenic or combinations of arsenic. The use of these colors for tinting furniture is likewise prohibited.

DR. RAINER RITTER VON SCHMERLING.

Regulations against arsenic and other dangerous paints have been in force in Saxony for many years. In 1856 the people were warned against a red pigment known as Munich red, cochineal red, and Pernambuco lake (Brazil red), and used for paper-hangings, colored paper, and for staining. Again in 1868 a warning was issued against window-blinds colored with various arsenicated pigments, which, being applied in a very superficial manner, were easily detached from the blinds as powder, so that the air became impregnated with poisonous molecules. According to the Saxon authorities, poisonous colors are prejudicial to health when not

CETEWAYO LAID OUT IN HIS HUT AFTER DEATH.

properly applied to the surface of the papers, or when not smoothed down or not varnished, or if the hangings are applied to damp walls to which they do not hold firmly, so that the pigment is liable to flake or dust off. But those colors are innocuous when applied to the walls of rooms if the walls are and remain dry, if the wall is dry before the painting, and the lime used is mixed with milk not over-diluted, or the color when dry is washed with a suitable fluid, such as water glass, etc. Colors of this class, especially the more injurious, viz., the greens and blues, should be altogether excluded from sleeping apartments, as well as from workrooms in which the air is highly saturated with aqueous vapor or impregnated with the fumes of vinegar, ammonia, chlorine, sulphuric acid, etc.

Poisonous colors when used in carpets or wall papers are attended by exceptional risk in Sweden, as the inhabitants live during winter in apartments which are almost hermetically sealed. A statute was issued by the King in 1876, which prohibits the manufacture and importation of arsenious acid or white arsenic in Sweden, unless the royal permission has been obtained. Wall paper, window blinds, Venetian blinds, tissues, artificial flowers, or other articles in water color, printed or painted in colors containing arsenic, are not to be kept or offered for sale. An elaborate list of poisonous colors has been prepared by the Swedish Board of Health, but the term "poisonous" does not seem to have a strict definition. Thus, for example, we find among the white colors considered to be obnoxious, bismuth-white and zinc-white, while a note states: "These colors when used as paints are perfectly harmless. Bismuth, even when followed in large doses, is inert, and the substitution of zinc whites, albissima, Charlton white, silicate paints, etc., for white lead is much to be desired."

It is also said that arsenic has been discovered in other colors besides the green copper colors, such as some of the most beautiful of the red drop colors, various gray colors used in printing wall papers, and in tar colors. According to the law of Denmark, arsenical preparations may not be used for staining, dyeing, or coloring stuffs, window blinds, Venetian blinds, artificial flowers, lamp shades, paper, etc., nor form part of a pigment mixed with glue, gum, size, dextrin, white of egg, etc., for walls of rooms or wall papers.

The Russian code of laws prohibits the importation as well as the manufacture in Russia of all wall papers which are covered with a thick coating of arsenical coloring matter, both opaque and glazed. There is an exception in favor of paper in which the pattern is traced in arsenical paint on a more extensive ground of non-arsenical coloring matter. Lists of injurious colors and harmless colors have been prepared, and the following plain method for detecting the presence of arsenic in articles colored or dyed has been issued:

For the purpose of testing green and other wall paper, in which the presence of arsenic is suspected, a small piece of such paper should be taken and cut into shreds, which are then to be placed in a wine glass. If the object of examination be coloring matter, a piece of the size of a pea should be taken and treated in the same manner; if a piece of tissue is under examination, a small shred of it should be cut off. The piece of paper, dye-stuff, or tissue must be created with caustic alkali (solution of ammonia), a teaspoonful of which must be poured over the object of examination. The liquid will assume a blue color, and, after five or ten minutes, half a teaspoonful of pure hydrochloric acid (chemically pure), which will give the liquid a light green hue, must also be poured into the glass. Finally, a piece of copper or a copper coin, previously polished with sand, is placed in the green liquid. If after the expiration of five minutes the copper shows on its surface a gray, glistening deposit, then the wall-paper, dye-stuff, or tissue contains arsenic; but if the surface of the copper remains red, there is probably no arsenic present. It must, in addition to this, be observed that all articles colored with arsenical paints emit, when burnt, a smell of garlic.

While so many countries have adopted measures to protect the inhabitants against poisonous colors, there are others which are as indifferent as England. France has no regulations, except in the case of articles of food, beyond a circular which has been issued by the Minister of Commerce cautioning manufactures, and explaining the responsibility they would incur in the event of accidents arising from the use of poisons. Belgium is also without a decree to restrict or regulate the manufacture, use, or sale of arsenical or other poisonous pigments employed in industry or in the decorative arts The same way be said of Greece, Italy, Holland, Portugal, Spain, and Switzerland. There is no federal law on the subject in the United States, and it may also be asserted that there is no State legislation or municipal enactment bearing on the matter.—*The Architect.*

CARBOLIC ACID.*

TAR, with what is obtained from it by distillation, is a complex product. We will only refer to two substances, viz.: Creosote, which is obtained from wood tar, and carbolic acid, which is obtained from coal tar; and though differing in composition, their action is very much alike.

Creosote is found in the products of dry distillation of wood, and of various vegetable as well as animal substances, and of benzoin resin, used in fumigation. Tar barrels, which have been burned in time of epidemics to purify the atmosphere, give out this substance, but would give a greater quantity if the flames were suppressed, and distillation only allowed.

The world has admired this substance without knowing of its existence; has sought for it, using various names to express it; wrapping it in bundles to carry around them, burning it in pastilles for fumigation, and sometimes in public in great bonfires. The most civilized people of olden times, kept in the products of tar the dead that they desired to preserve to a joyful uprising.

Thus we see that the antiseptic properties of tar were known at a very early period, but the process of extracting its subtle essences, and bringing them into general use, was reserved for the nineteenth century.

Creosote was discovered in 1832, by Reichenbach; it is officinally described as a peculiar substance obtained from wood tar. It is a colorless, oily liquid, of a peculiar, disagreeable, penetrating odor, resembling that of wood smoke, and has a burning, acrid taste, which is perceived throughout the whole extent of the buccal, nasal, and pharyngeal mucous membrane. It burns briskly in the air, emitting large volumes of smoke. It congulates albumen, but exerts no action upon fibrin. It is sparingly soluble in water, but readily so in ether, alcohol, acetic acid, and the essential oils. It acts as a solvent of iodine, phosphorus, sulphur, and the resins. Its action, both upon animal and vegetable organisms, is so identical with that of carbolic acid, that there is no real reason for giving it the preference which some do, even if it could be obtained pure, which is nearly impossible. In fact, *pure* creosote is almost a myth. Dr. Brophy says: "Of 25 samples of creosote, purchased from as many different dealers, I find on examination that, with one exception, all contain carbolic acid; some were pure carbolic acid." This being the case, is it not preferable to use pure carbolic acid, and call it so, rather than use a mixture and call it creosote? They may be distinguished from each other by the following tests:

Carbolic acid becomes solid at ordinary temperatures, while 17° below zero does not affect creosote.

Carbolic acid is soluble in water, 1 part in 95, or 1 in 20 of boiling water, and this solution is colored a deep violet purple by the addition of a solution of ferric chloride. Creosote is soluble in water, 1 part to about 125, and is colored brown by ferric chloride. An alcoholic solution of carbolic acid is colored a light olive green by ferric chloride; an alcoholic solution of creosote, a dark sea green. Carbolic acid forms a jelly when shaken with collodion; creosote does not.

Carbolic acid was discovered by Runge, in coal tar, in 1834, and given the name it now bears. It is procured from coal tar by distillation, at a temperature of from 300° to 400° Fah. In 1841 it was investigated by Laurent, who gave it the name of hydrated oxide of phenol; it was afterward called phenic acid, and, as it is closely related chemically with the alcohols, it was called by some phenylic alcohol. It is, however, best known by the name given it by its discoverer.

Before its use separately, its virtues were exhibited in the crude material known as coal tar, in 1844, by M. Bayard. About 1860, Kuchenmeister used it under the name of "spirol," both in medical and surgical practice, and as a means of arresting putrefaction and preventing the development of fungi. In 1863, Dr. Lemaire issued a treatise upon phenic acid, illustrating its power of preventing fermentation and putrefaction, and its application to medical and surgical uses. In 1865, M. Declat illustrated the power of the acid to destroy the microphytes and microzoaires, developed during fermentation and putrefaction, and of preventing the changes which constitute these processes. After this it came into general use, both in this country and Europe. Its vogue is chiefly to be ascribed to Prof. Lister, who commenced its use as a surgical dressing in 1865.

Carbolic acid in its pure state is solid at ordinary temperature, and is either in acicular crystals or crystalline masses; colorless when pure, but when impure a reddish brown, or becoming so on exposure to light and air, which is said to be caused by the presence of xylic and cresylic alcohols, which always accompany it in its impure state, and adhere to it tenaciously. On exposing the crystals to the air they attract moisture, and deliquesce. It becomes liquid by the presence of water in very small quantities. With regard to its solubility in water, there is a great diversity of opinion in regard to the proportions. It is claimed to be soluble in 15 per cent. of water, and from that, all the way up to 95 per cent. I find, by experiment, that the crystals will absorb 10 per cent. of water by weight, and become perfectly liquid. After that proportion of water has been taken up, there is no union of the acid and water until 95 per cent. of water has been added, at which point the acid is entirely dissolved, but not before. It is, however, perfectly soluble in 20 per cent. of boiling water. It is very soluble in ether, alcohol, acetic acid, glycerine, and the fixed oils. It is inflammable, burning with a reddish flame and dense volume of smoke; it melts at from 95° to 160°, and boils at from 359° to 370° Fah. Nitric acid converts it into picric acid, and it is largely used in its manufacture. It reduces many metallic salts, especially those of silver and copper; with alkalies it forms acid salts, and combines readily with iodine, bromine, quinine, etc. As generally sold, if pure, it is an oily, colorless liquid, with a strong smell like creosote, and having like it a pungent, acrid taste.

With regard to the propriety of calling it an acid, it does not respond to the usual test with litmus paper, when tested at full strength, but in a solution of 5 per cent. carbolic acid and 95 per cent. of water, we get a decided acid reaction, coloring blue litmus paper red, almost instantly. Why the addition of water should change a neutral solution to an acid, I am unable to state. I discovered this acid property accidentally, about a year ago, while making some experiments. It may have been known to others, but I have seen no account of it.

As a therapeutic agent it is invaluable, as it possesses stimulant, narcotic, irritant, styptic, antiseptic, and escharotic properties. It unites with albumen and gelatine, forming with them insoluble compounds. It has remarkable antiseptic powers, and consequently is a valuable topical application, in cases attended with offensive purulent or other discharges, but it is not a disinfectant, as generally considered. It prevents decomposition, but does not destroy or render inoffensive the products of decomposition. It is commonly used as a deodorizer, but it is not one; it has *no* action upon foul emanations. Its operation consists in preventing their generation, by arresting putrefactive changes in the substances which exhale them. Lemaire claims that these changes are due to septic infusoria in the atmosphere, which, "when admitted into wounds, ulcers, etc., produces a decomposition in the part and its secreted fluid, aiding the formation of pus, that this decomposition is effected by a vital action, similar to the production and multiplication of organisms in fermentations; that carbolic acid in small doses has the power of preventing and arresting any such decomposing effects from these organisms, by at once and immediately destroying the life of the organisms themselves."

Whether this view be correct or not, it is undeniable that it will prevent putrefaction, or arrest it where it has already begun, and when putrefaction ceases the foul emanations cease also, and this is, undoubtedly, the way it works when applied to drains, sewers, etc., and decayed substances, whether animal or vegetable.

All the lower forms of vegetable organic life are destroyed by carbolic acid. It arrests fermentation, destroys mould and mildew, and prevents the germination of seeds in water containing a 100th or 200th part of this acid. A strong solution applied to the roots of trees and shrubs kills them, and, if to the flowers, leaves, and fruit, these die.

On animal organisms a very small proportion of it in water containing bacteria, amœba, and other infusoria speedily destroys them. It is equally destructive to the life of ascarides, earth worms, caterpillars, fleas, moths, ants, and other insects. Fish, frogs, and leeches die speedily in a solution of it, and two or three drops applied under the wing of a sparrow produce convulsions and death. In the case of dogs, a 5 per cent. aqueous solution administered causes them to fall, cough, become convulsed, and then paralyzed in both sensation and motion; the acid is exhaled in breathing, and they gradually recover. One-half fluid drachm dissolved in twelve fluid drachms of glycerine, and thrown into the stomach of a dog, caused all the above symptoms, and, in addition, a bloody froth was ejected, and death ensued suddenly in ten minutes after administration. After the death of animals from poisonous doses, extreme congestion is found of the brain and its membranes, alimentary canal, and the lungs. The blood is not congulated. On man, when six or eight grains in a wine-glass of water are taken, a sense of numbness is felt on the lips and in the mouth, followed by a sensation of coolness. If the stomach is empty, slight nausea and an uneasy sensation in the abdomen follow, with vertigo, singing in the ears, and slight deafness. When swallowed by accident or design, the mucous membrane appears as if brushed over with a strong solution of nitrate of silver, and becomes hard and dry, like leather. This change in the condition of the mucous membrane is due to the power of carbolic acid to coagulate the albumen of the tissues. From medicinal doses, a cooling, grateful effect is felt in the stomach. Cases of poisoning have resulted from local applications. The warnings of danger, which may be expected when the remedy is brought in contact with the tissues at any point, are, besides the local irritation, sudden vertigo, contracted pupils, pallor of the face, difficult respiration, and feeble circulation.

When the dose is a fatal one, unconsciousness quickly follows; the breathing becomes stertorous, the surface grows cold, the action of the heart more and more feeble, and death finally occurs from failure of respiration. Convulsions occur in animals, but in man this symptom is lacking. The poisonous effects of carbolic acid are remarkably uniform for the same dose. An ounce or more, taken by an adult, produces an intense burning pain in the throat and œsophagus, followed by staggering as from intoxication, and then complete insensibility. The face is pale, lips and hands livid; the pulse, sometimes above and sometimes below the normal rate, is soft and compressible; respiration stertorous, tongue swollen, and a discolored foam on the lips. The skin, breath, and urine smell strongly of carbolic acid. Death has occurred in a few minutes; in most of the fatal cases in from one to three hours, and they hardly ever live two days. It affects the urine, even when applied locally, and one of the earliest indications of toxic action is a dark greenish, blackish, or smoky hue of the urine. Stadeler caims to have discovered carbolic acid in normal urine, but this is disputed. In cases of poisoning, the stomach should be emptied as soon as possible, and albumen in the form of fresh eggs, largely diluted with cold water or milk, freely administered. Saccharate of lime is a chemical antidote, and in cases of poisoning may be used freely. Oils and glycerine should not be given, because they favor absorption, but vegetable demulcents used freely, in order to protect the mucous membrane as much as possible. Atropia is a physiological antagonist of great value. The application externally has sometimes been fatal. Three women used crude carbolic acid for itch, mistaking it for sulphur ointment, applying it all over the body with a sponge. One died in three hours, another in two days, and the third recovered after an illness of three weeks. Another case of a female child, who sat down upon a block which had been freely sprinkled with a solution of an ounce of acid to one quart of water. Blistering, followed by ulceration of the labia and buttocks, took place, and the child died on the tenth day.

For internal use, the dose is from one-fourth to two grains, in a wine glass of water. One or two drops in a glass of water will arrest nausea and vomiting. Cholera morbus and cholera infantum are frequently checked by its exhibition. Eructations or gas, and flatulence, due to fermentation of food, are arrested by it. Inhalations of carbolic acid spray, of the strength of 1 per cent., are used in chronic nasal catarrh, hay fever, and whooping-cough, which is said to be due to the fact that it destroys the minute organisms which cause the morbid action in these maladies. Schnitzler, of Vienna, employed the subcutaneous injection of it in more than one hundred cases of consumption, using from one-eighth to one-fourth of a grain once, and, in some cases, twice daily. In many cases the fever lessened, pulse became slower and stronger, and night sweats diminished.

Based on the germ theory of disease, it has been used with some success in typhoid fever, diphtheria, scarlet fever, and erysipelas. In parasitic skin diseases a weak solution is very serviceable. It is largely used in surgery in carrying out the antiseptic system of Prof. Lister, who, believing that suppuration, pyæmia, and various other troubles connected with open wounds arise from the irritation of minute germs contained in the air, devised a process by which the air, before reaching the raw surface, is filtered through carbolic acid, and thus deprived of its irritating properties. He prevents the access of air during operations, by surrounding the part with an antiseptic atmosphere, composed of a sprayed watery solution of carbolic acid, 1 to 40. The instruments and fingers of the surgeon are washed with carbolized oil, and the arteries tied with carbolized catgut ligatures. By adopting these precautions, and the careful dressing of wounds, he has obtained excellent results, not only after ordinary operations, but in chronic abscesses, and various diseased conditions connected with the joints.

Strong carbolic acid, applied to the surface of healthy skin, causes an immediate tingling and burning sensation; the spot becomes white, and the skin around it is tinged with red; the symptoms are similar to those resulting from the application of a powerful caustic. In a few days there is exudation from the surface, sometimes dry and scaly, but frequently there is formation of pus. Dr. Bill was the first to demonstrate the anæsthetic properties of carbolic acid. He states that "by applying a solution of it to the integument, insensibility to pain may be sufficiently induced to permit free incisions without suffering." It coagulates blood, but does not stop bleeding. In solution, it congulates albumen, arrests fermentation, instantly destroys the lower forms of animal and vegetable life, and in very small proportions prevents mouldiness in vegetable juices, and protects animal substances from putrefaction. In a solution of 1 to 500 it destroys vegetable mould, and is equally destructive to minute organisms. According to Dr. Neuman, a solution of 1 per cent. is sufficient to destroy bacteria. It was mentioned here, last year, that bacteria had been seen crawling over crystals of carbolic acid. I think the crystals, like those of many other acids, are inert, and must be in solution to produce an effect. It is very certain in many cases we get better results from a diluted solution than from full strength.

It seems to have the effect of promoting growth of healthy granulations, and hastening healing processes of wounds. It relieves pain without causing inflammation, and arrests suppuration. Its application should be repeated as long as pus is formed on the surface of the wound, but should not

* Read before the New York Dental Society, by Frank Bennett, M.D.S., of Rochester, N. Y.—*Dental Register.*

be applied so long as the eschar from the former application remains attached. It is an irritant, and if applied long enough to the skin will cause sloughing. It is an escharotic, and if applied to the integument or mucous membrane, produces a burning sensation of short duration, and there is formed a whitish superficial eschar, said to be due to the coagulation of albumen, which subsequently becomes brownish and drops off. As regards the strength in which carbolic acid should be used, it must be governed by the exigencies of the case and the judgment of the operator. For external use where escharotic action is desired, as in gangrenous or specific ulcers, it may be used in the strongest liquid form; but for ordinary skin diseases, a solution of from 1 to 5 per cent. is sufficient, also where a gentle stimulation is desired in order that the parts may take on recuperative action. Where prompt, decisive action is required, and heroic treatment demanded, it may be used full strength; but where only gentle stimulation is desired, a 5 per cent. solution is sufficient. Ulcers and suppuration, whether on the outer surface or from the mucous passages, are benefited by its use, and fistulous ulcers, especially those connected with the mouth, are generally controlled by it. It has been highly recommended as a dentifrice in carious teeth and offensive breath. On account of its anæsthetic properties it relieves pain caused by an exposed pulp almost instantly, and is useful to apply to the pulp before applying arsenic, when it is necessary to destroy it. Some good operators claim that they are able to extirpate the pulp alive, almost painlessly, by working carbolic acid in between the pulp and walls of the canal with a fine broach.

Where the nerve is exposed, and it is desirable to save it alive, it should never be used full strength, as its escharotic action may cause sloughing, and being confined under the material used for capping, the death of the entire nerve is apt to follows; but a solution of 1 to 5 per cent. may be used with great benefit in such cases, as it is a gentle stimulant, slightly antiseptic, and will not cause sloughing and death.

Applied in full strength to a cavity just prepared for filling, a painful burning sensation is experienced for an instant, and the cavity is not only less sensitive, but that portion of the tooth seems to lose a portion of its conductivity, so that it is less sensitive after being filled than it would be if it were not used. This is said to be due to its coagulating the contents in the ends of the freshly cut tubuli, and thus breaking the connection of conductive power between the filling and the nerve. It is also claimed that its use in cavities before filling renders inert any small particles of decayed matter that might possibly remain. Brophy says: "It is a most excellent remedy to apply to carious teeth during the process of excavating, to enable us to more clearly see the extent of the caries; in many cases we are surprised, upon moistening the cavities with it, to find carious tissue, which, if permitted to remain, would soon render another operation necessary."

Sensitive cavities are rendered much less so by applying carbolic acid, full strength, then inserting a gutta percha filling; allowing this to remain a few days, the cavity may be excavated with very little pain. It can be used in this way as an obtunder without endangering the pulp.

It is an excellent dressing for nerve canals after removing the pulps, as it closes the ends of the tubuli by coagulating the contents; but as in destroying the pulp we sometimes destroy the contents of the ends of the tubuli or the ends of the so-called soft fibers of the tomes, it would be safer to slightly enlarge the canal so as to reach what has been called the "dead line," before applying the carbolic acid.

It is the custom of many operators before filling nerve canals to close the apicial foramen with a small pledget of cotton, saturated with carbolic acid, on account of its antiseptic properties. This is condemned by some, but where carefully done the results are almost uniformly good. It has been claimed that a saturated solution of iodine in creosote or carbolic acid has been successfully used in cases where there is wasting of the gums and processes, with exudation of pus and loosening of the teeth, changing the pus-producing to a plasm-producing surface. It stimulates those parts which are weak, but still have vitality enough to be restored, and destroys those which have not. It should not be applied oftener at first than once a day, and after a few applications once in two or three days. It should be applied carefully, to avoid coming in contact with healthy parts, and covered with a saturated solution of glycerine and tannin.

In the treatment of nearly all cases of abscess, where it is not accompanied by necrosed bone, carbolic acid may be regarded as nearly a specific, but where necrosis is present other treatment is indicated. In using it where it comes in contact with the skin, its caustic action can be overcome by rubbing the parts with oil. In the treatment of alveolar abscess, the dentist comes to regard it as a sheet anchor. Many other remedies have been used, but none of them seem to take its place. There is a diversity of opinion concerning the strength of the solution to be used in such cases. Where there is a fistula I always use full strength, pumping it with a piston through the root, until it comes through the fistula clear and free from pus. If necessary I repeat it in two or three days, but rarely have to use it more than twice. It should not, however, be used until a disinfecting agent has been applied in the root, otherwise the effete matter in the tubuli will be coagulated, and remain to give rise to trouble through the tubuli into the lacunæ and thus through the cementum. These are dead men that sometimes will not rest quiet in their graves.

The uses of carbolic acid are so numerous as to make it impossible to refer to more than a few in a paper of this kind. In very small quantities it is azymotic, *i. e.*, fatal to all the lower orders of animal and vegetable life; it is also antiseptic, *i. e.*, opposed to putrefaction or decay, even preserving the organisms which it kills. By good authorities all epidemic, contagious, and infectious diseases are believed to be zymotic, *i. e.*, of the character of a fermentation dependent upon living organisms; now, as all the processes of decay and putrefaction are dependent upon fermentations, which are caused and kept up through the agency of cell life, or organisms of a low vitality, in fact are also zymotic, a good key to its powers and uses is at once obtained, and at the same time a good guard against its misapplication.

The hurtful material in foul emanations and foul air may be inodorous and insensible, but is endowed with vitality, and the laws of nature tend to direct the material to a soil and climate fitted for its functions of germination and reproduction. If the azymotic could be distributed in the same way there would soon be an end of zymotic disease, but with it an end of all fermentation and an end of the present order of creation, in which fermentation performs an indispensable part.

Since writing this paper I have been informed by Dr. T. A. Smith, of Bloomington, Ill., that common vinegar is a perfect antidote for the action of carbolic acid, internally as well as externally. I have had no opportunity to verify his statement with regard to its internal action, but in several cases externally it has been applied with the most satisfactory results, stopping the action of the carbolic acid at once, and no unpleasant effect following.

THE ANALYSIS OF CHILI SALTPETER.

THE soda saltpeter which is brought from South America and called Chili saltpeter is extensively employed both for making other nitrates, including nitric acid, and for fertilizers. In both cases it is important to know just how much nitrogen it contains, for upon this its value entirely depends.

If it contains but little chloride of sodium, not over three per cent., and is free from organic matter, the nitric acid can be estimated by simply igniting it with sand. Otherwise the nitric acid must be reduced to ammonia, and the latter estimated in the usual manner.

I. BY IGNITION.

From 6 to 8 grams are ground up in a mortar and sifted, then dried in an air bath at about 125° C. (257° Fahr.), and the loss calculated as moisture. Next 4 or 5 grams of very fine quartz sand are strongly heated in a platinum crucible, cooled in a desiccator, and the total weight of sand and crucible noted. About 1 gram of the dried saltpeter is poured on the surface of the sand and mixed in with a platinum wire. The crucible is then heated very gently with the lid on, then more strongly, but only to such a degree that about one-third of the crucible is dark red. After heating for 15 minutes, the crucible is removed from the flame, cooled in a desiccator, weighed, ignited for five minutes more, and so on until it ceases to lose weight. Generally two weighings will suffice. The loss of weight is to be calculated as N_2O_5, or anhydrous nitric acid.

A sample that contains 96·40 per cent. of $NaNO_3$ will show a loss corresponding to 61·29 per cent. N_2O_5, or 15·89 of nitrogen.

II. REDUCTION.

Dissolve 10 grams of the pulverized salt in water, and make it up to a liter. Take out 25 c. c. with a pipette and transfer to an Erlenmeyer flask, which is connected with a receiver containing 20 c.c. of normal sulphuric acid. Put two or three spirals of zinc and iron in the flask, and then let 50 c. c. of a 14 per cent. soda solution flow through a tube inserted in the rubber stopper, and close the tube. Shake frequently, and keep it at the ordinary temperature for about 15 hours. The reduction then goes on slowly and uniformly. At the expiration of this time heat *carefully* to prevent foaming, and the ammonia formed will distill over into the receiver. After 30 or 45 minutes the operation is ended, and air should be drawn through the apparatus to drive out the residue of ammonia and bring it in contact with the sulphuric acid. The acid is then titrated back with baryta water. The 20 c.c. of normal sulphuric acid corresponds to 0·09799 gram of nitrogen. Each c. c. of BaO corresponds to 0·003228 gram of nitrogen to be subtracted.—*Chemiker Zeitung.*

THE MECHANICAL THEORY OF MAGNETISM.

WHAT is magnetism, according to this expert philosopher? It is an inherent quality of the molecules of matter, as determined and constant as that of their gravity, affinity, or cohesion, and like these qualities it differs in degree with every kind of matter. He does not attempt at present to define it closer than this.

We cannot tell what gravity is, neither need we say what magnetism is. All Prof. Hughes says is that every molecule in nature is a little magnet imbued with a certain polarity varying in degree but constant for each substance, in virtue of which it has a north and a south pole along the same axis, and that the only change that takes place is a change in the direction of this polar axis. When these molecules are symmetrically arranged by some external directing influence, so that all their poles lie in the same direction, we have *evident magnetism.*

Iron becomes a magnet in virtue of the fact that its molecules are free to move under the influence of external magnetic action, while copper is not a magnet because its molecules are immovable and irresponsive to the same cause. Steel becomes permanently magnetized because its molecules are rigid, and retain the axial direction impressed upon them.

Soft iron is readily demagnetized because its molecules have great freedom of motion. Coercive force is therefore simply absence of freedom of molecular motion—it is, indeed, molecular rigidity. The extent to which the axis of polarity can be deflected from its normal direction is its *point of saturation.*

Evident magnetism is the symmetrical arrangement of the polarized molecules along one line; *neutrality* is symmetrical arrangement of the same molecules in closed curves. In both cases the sum of the magnetic influence of all the molecules is the same; but in evident magnetism it is directed outward, in neutrality it is directed inward. Remaining magnetism is partial neutrality.

The experimental way in which Prof. Hughes demonstrated these conclusions is the most beautiful investigation he has yet made. He proves the existence of the same polarity in the atmosphere and in the ether, and he attributes diamagnetic effects to the higher magnetic capacity of the ether than of the substances suspended in it. It is therefore a differential action.

Molecules, moreover, have inertia—they resist being put in motion; and when in motion they resist stoppage—they possess momentum. The direction of the axis of polarity can be displaced by the physical forces, such as mechanical stress, heat, or electricity. He shows that mechanical motion, heat, and electricity are of similar kind—they are vibratory or some mode of motion.

Magnetism, however, he considers not to be a mode of motion, and therefore it is not a physical force. It is simply an arrangement of the molecules of matter in symmetry or dissymmetry under the influence of some physical force. He seems to imply, though he does not directly say so, that the influence of electric currents upon magnets is not due to any direct action between them, but to the fact that the currents have polarized the ether in which both are suspended.

His views are very broad and highly suggestive, but there are some points that are not clear and that demand further elucidation. Why, for instance, does mechanical elongation and contraction take place when bars of iron are magnetized and demagnetized? How can heat and strong sonorous vibrations be produced unless there be a considerable expenditure of energy? How does he account for the attractive and repulsive properties of magnets, and for magnetic induction?

He has certainly wrested magnetism from the realms of hypothesis and brought it within the domain of theory. The days of Coulomb and Poisson's fluids and Ampere's elementary currents of electricity are over; the molecular character of magnetism is experimentally established; but what is a molecule, and how becomes it polarized unless it be in rotation? How does the external directing influence act? We are also inclined to ask, Has Prof. Hughes sufficiently grasped Ampere's theory? It was purely mathematical, based on the assumption of the circulation of currents around each molecule. He goes no further than Ampere did, for he has not answered the question, What is polarity? In fact, his polarized molecules are all little magnets, and no theory of magnetism will be complete until it explains these little magnets. Thus the difference between Ampere and Hughes is the difference between a current and a magnet.

However, on the assumption that a molecule is a magnet, Prof. Hughes has built up a very complete theory, which he has demonstrated experimentally in a way that places him in the very front rank of experimental philosophers.—*Nature.*

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